The Journal of Bone and Joint Surgery

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The British Orthopaedic Association
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The Canadian Orthopaedic Association
American Society for Surgery of the Hand
New Zealand Orthopaedic Association
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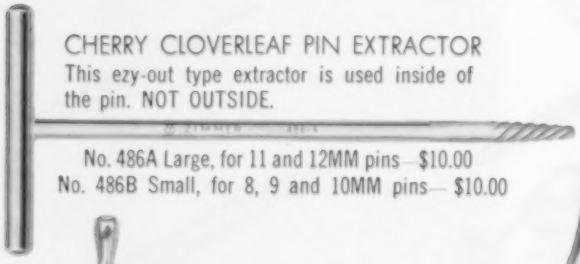

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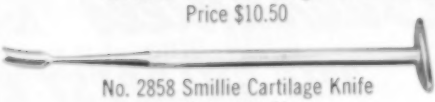

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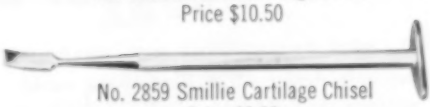

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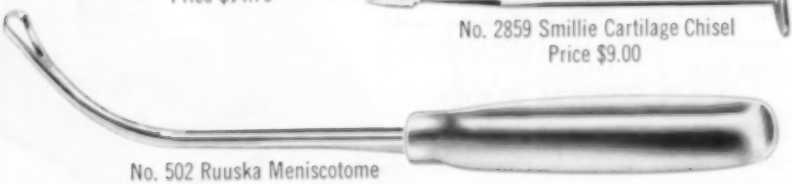

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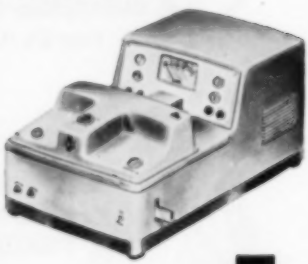

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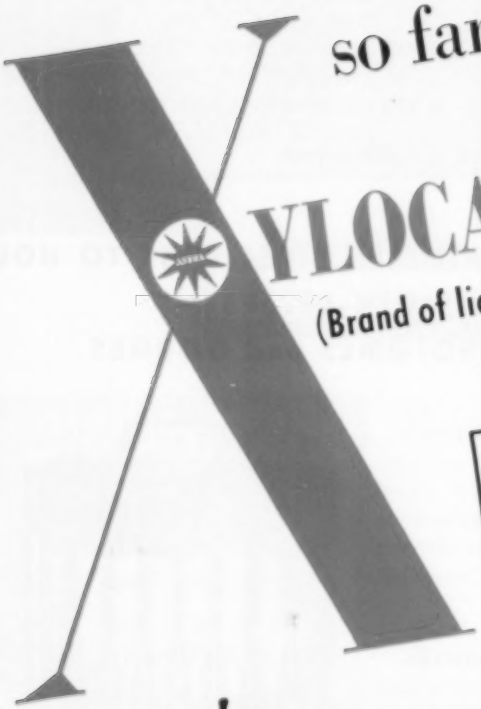

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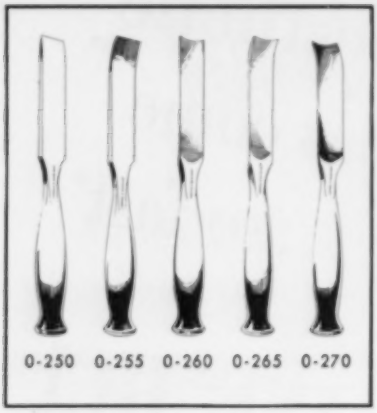

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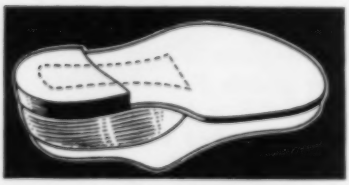

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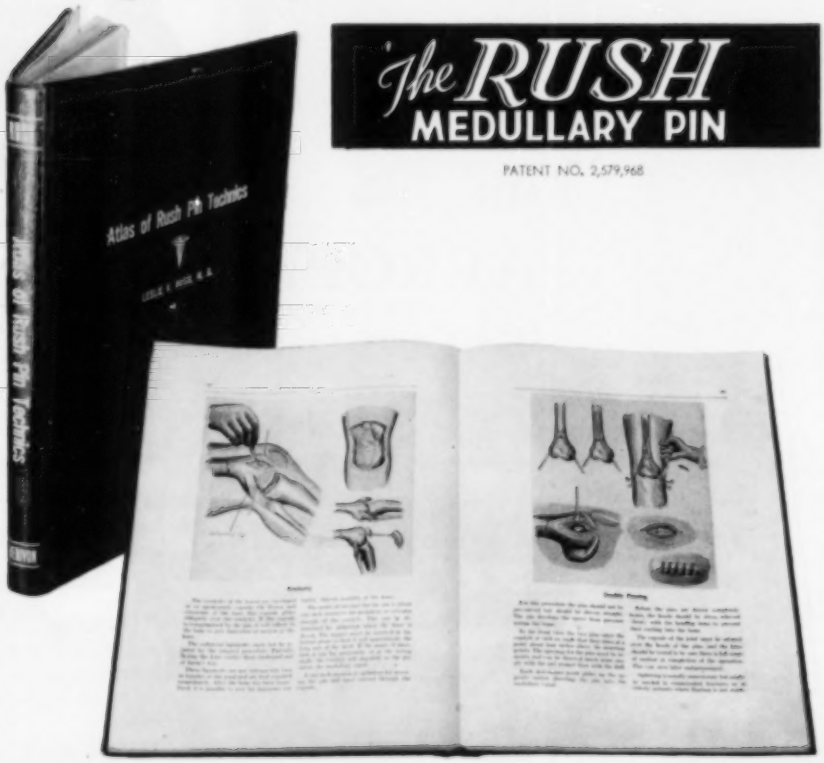

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1. Rigler, S. P. and Adams, W. E.: Experience with a new sprayable plastic as a dressing for operative wounds, Surg. 36:792 (Oct.) 1954. (University of Chicago Clinics, Chicago, Surgical Service).

2. Choy, D. S. J.: Clinical trials of a new plastic dressing for burns and surgical wounds, Arch. Surg. 68:33 (Jan.) 1954. (Bellevue Hospital, New York, Third Surgical Division—Dr. John Mulholland, chief).

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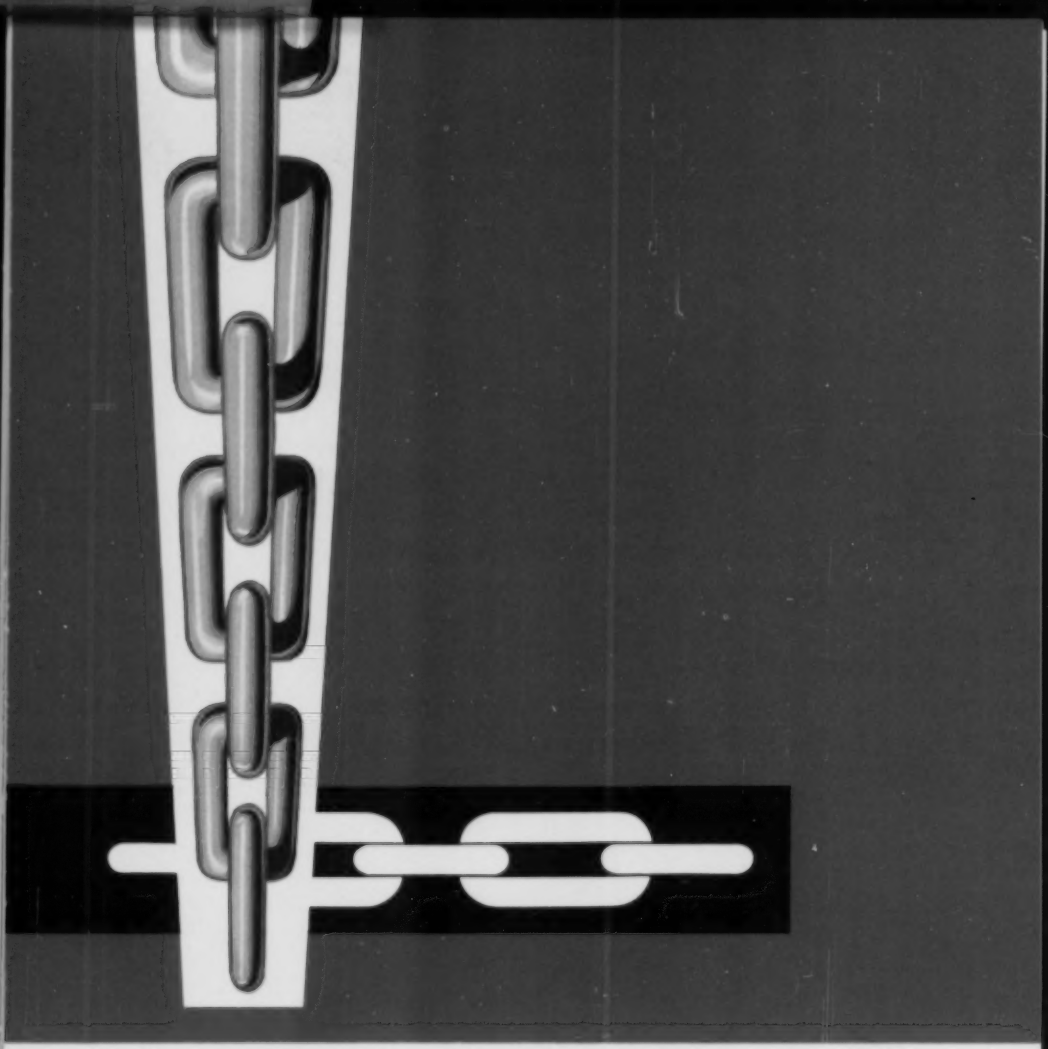

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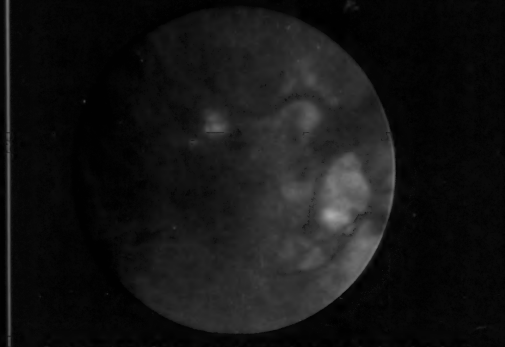
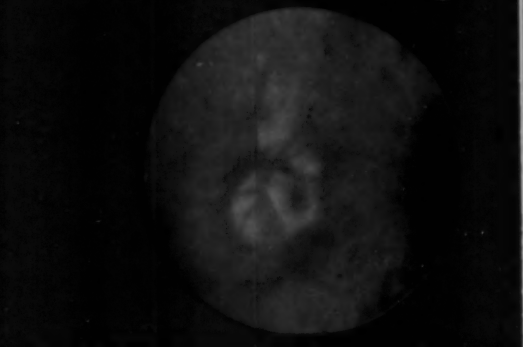


Anticipation of recurrent hemorrhage and visual defect is high in hypertensive patients.



After Adrenosem therapy. Note exudative areas. Maintenance therapy checks further hemorrhage.

Mastoidectomy with a bloody field obscures view, requires frequent suctioning.

After Adrenosem therapy. Note clearer operative field with minimized bleeding.

Multiple extraction without Adrenosem. Note seepage. Frequent suctioning is required.

After Adrenosem therapy. Note clearer field. Minimal bleeding facilitates surgery and promotes healing.

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Adrenosem is specific for conditions characterized by increased capillary permeability allowing oozing and seepage bleeding. To prevent seepage bleeding due to capillary permeability it is necessary to maintain tone of the capillary wall. This is supported by Pappenheimer's[1] work on capillaries. In cases of capillary permeability it is postulated that the connective material between the cells, which form the capillary wall, has lost its tone and allows the erythrocytes to pass through.

To confirm the action of Adrenosem in establishing capillary integrity the cheek pouch of a hamster was irritated with snake venom, which has the property of making the capillaries more permeable.[2] A great many petechiae appeared on the surface and a 500 X magnification showed the capillaries with extravasation of erythrocytes. Another animal was treated with Adrenosem, and 30 minutes later, the same amount of snake venom was used to irritate the cheek pouch. Microphotographs of the same 500 X magnification show the intact capillary walls and the actual blood cells coursing through the capillaries, without signs of escaping erythrocytes.

Fig. 1—*Trauma from snake venom produces hemoconcentration and stasis, indicative of altered vascular permeability.*

Fig. 2—*Trauma does not produce petechiae following Adrenosem injection.*

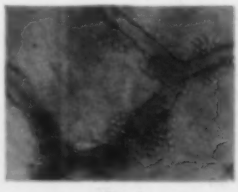

Fig. 1

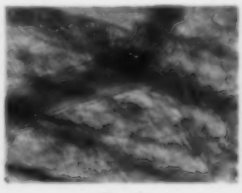

Fig. 2

Action

A systemic hemostat, Adrenosem restores capillary integrity by maintaining tone of intercellular tissue in the capillary wall. Adrenosem is unlike any hemostat available to medicine.[3,4] It does not interfere in any way with the blood clotting mechanism or its component parts. There is no sympathomimetic action and the blood pressure, cardiac rate and volume are not affected. Adrenosem may be administered simultaneously with any type of anesthetic, anticoagulant or vitamin K and heparin. Adrenosem will not interfere with the action of these agents.

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While the hemostasic action of epinephrine and related compounds has been recognized for a long time, certain characteristics limited their usefulness. A product of the metabolism of epinephrine seemed to offer the most promise. Given the name, Adrenochrome, this compound was studied extensively in both European and American centers. The handicap to wide use of Adrenochrome was its instability, so efforts were directed to find a stable modification that would retain the physiological activity. The answer to this proved to be the monosemicarbazone of Adrenochrome. Further research demonstrated that this compound could be made soluble enough to be practicable as an injectable solution, by transforming it to a sodium salicylate complex. This process has made possible Adrenosem Salicylate, a potent therapeutic agent which fills an important need in medicine.

1 *Pappenheimer, John R.: Passage of molecules through capillary walls, Physiol. Rev. 33:387-423, 1953.*

2 *Fulton, M. D., Department of Biology, Boston University: Personal communication, 1954.*

3 *Sherber, Daniel A.: Adrenochrome complex in the control of bleeding, Am. J. Surg. 86:331-335, 1953.*

4 *Roskam, J.: Arrest of Bleeding, Chas. C. Thomas, Publisher, Springfield, Ill., 1954.*

5 *Peele, J. G.: Adrenosem in the control of hemorrhage from the nose and throat (in press).*

6 *Bourgoyne, J. R. and Riddle, A. C., School of Dentistry, University of Tennessee: Personal communication, 1954.*

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• to control mild, low-grade bleeding:
one ampul (5 mg.) every three or four hours until bleeding is controlled; then 1 to 5 mg. orally four to five times daily until bleeding ceases.

• maintenance dosage to prevent bleeding in conditions where small vessel integrity may be impaired:
1 to 5 mg. orally t.i.d.; if bleeding ensues, dosage may be increased 1 to 5 mg. orally every three or four hours; if bleeding persists, oral dosage should be supplemented with one ampul (5 mg.) daily.

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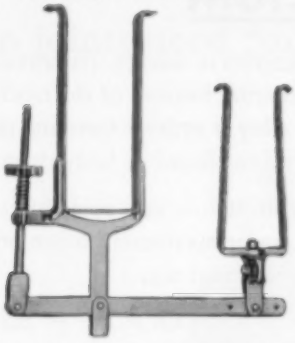

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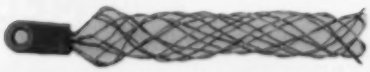

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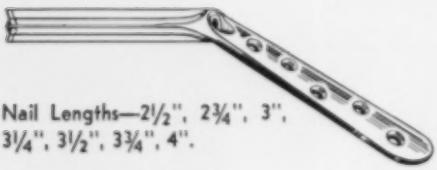

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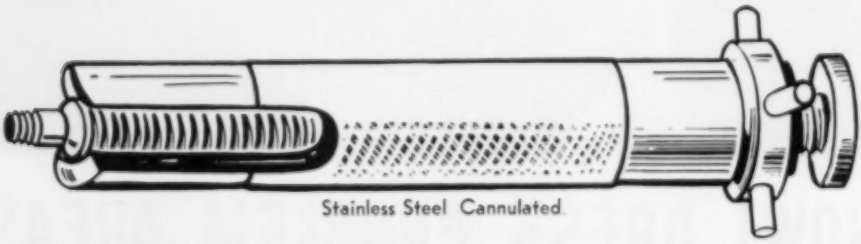

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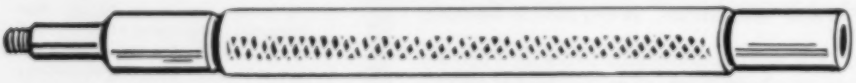

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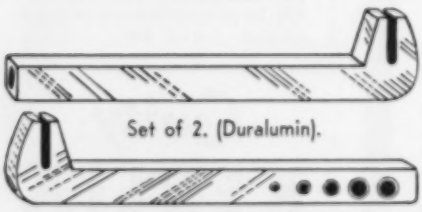

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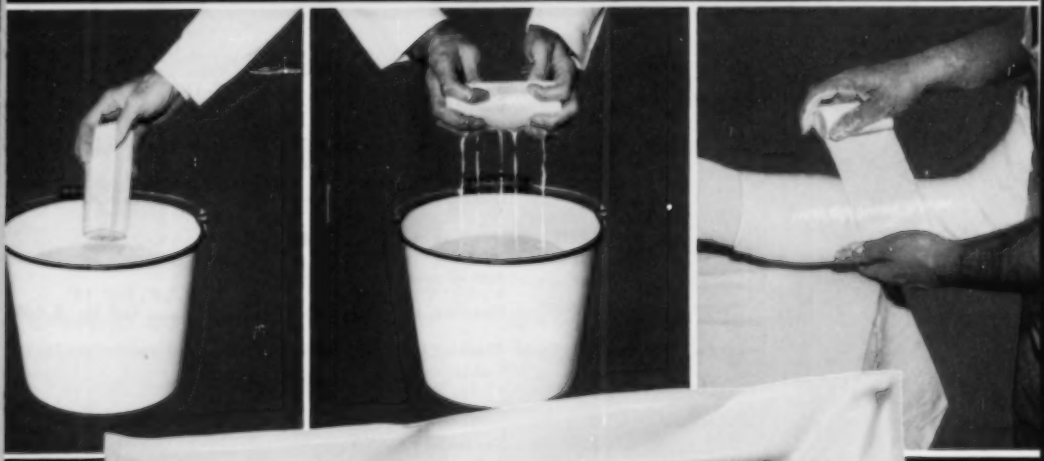

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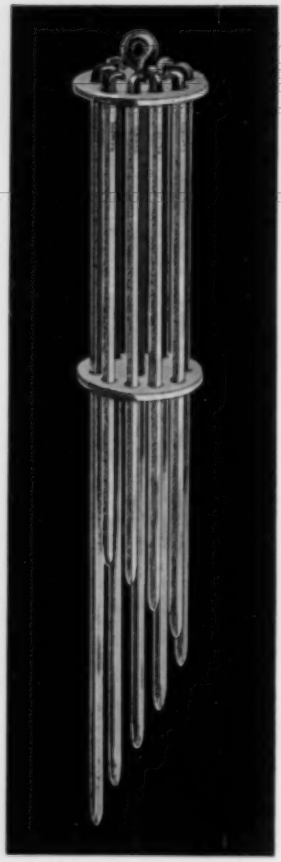

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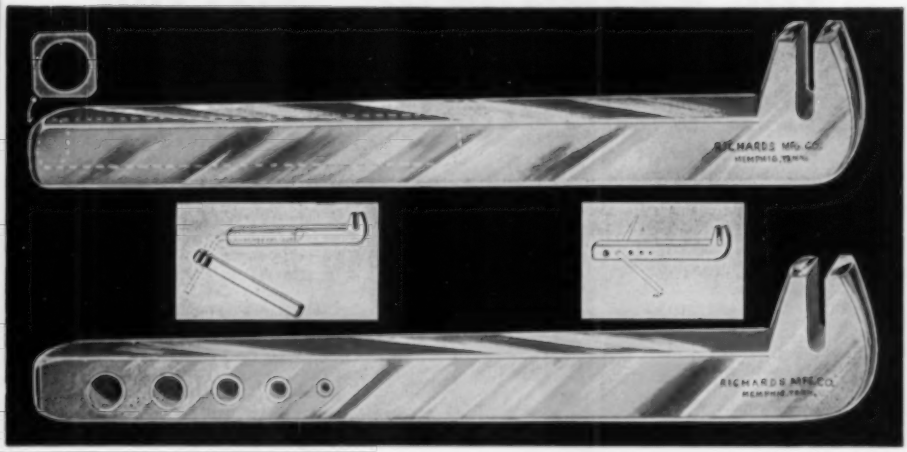

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They will not mark, mar or scar bone plates, nails, pins or any other object

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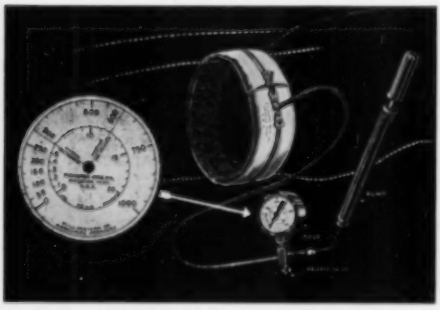

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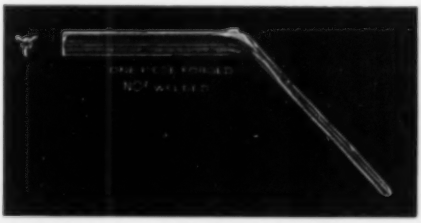

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Nail Lengths: 2½", 2¾", 3", 3¼", 3½", 3¾", 4", 4¼" 4½", 5".

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USED FOR:

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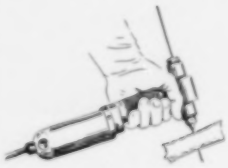
THE RICHARDS ELECTRIC BONE DRILL is a well-balanced, powerful, yet light weight precision instrument designed to reduce the labor and time element for the surgeon. Various possible uses are illustrated. Easily sterilized by autoclaving. It may be used either with or without the right angle head. The drill motor without the right angle head develops a maximum speed of 1100 RPM with an approximate power rating of 3/8 HP. The drill motor unit is complete with 1/4" chuck. The right angle head is cannulated so that threaded pins or wires can extend through it. A chuck at either end provides both clockwise and counter-clockwise rotation. Powerful gears reduce the speed to 550 RPM maximum in the right angle head, the correct speed for drilling bone. Nearly 3/4 horsepower is developed here even at the lowest speeds. THE RICHARDS BONE DRILL is unconditionally guaranteed for one year against defects in workmanship and material.



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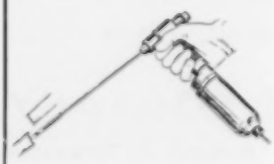

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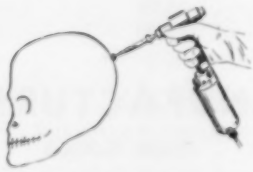

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When you specify the Pfizer antibiotic of your choice *Stress Fortified* with the B-complex, C and K vitamins recommended by the National Research Council, be sure to write SF* on your prescription

antibiotics *Stress Fortified* with vitamins include:

®Terramycin-SF
Brand of oxytetracycline with vitamins
CAPSULES 250 mg.

®Tetracyn-SF
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ORAL SUSPENSION (fruit flavored)
125 mg./5 cc. teaspoonful

Pen-SF*
Brand of penicillin G potassium with vitamins
CAPSULES 200,000 units

The minimum daily dose of each antibiotic *(1 Gm. of Terramycin or Tetracyn, or 600,000 units of penicillin)* **Stress Fortifies the patient** *with the stress vitamin formula* **recommended by the National Research Council:**

Ascorbic acid, U.S.P.	300 mg.	Calcium pantothenate	20 mg.
Thiamine mononitrate	10 mg.	Vitamin B_{12} activity	4 mcg.
Riboflavin	10 mg.	Folic acid	1.5 mg.
Niacinamide	100 mg.	Menadione	
Pyridoxine hydrochloride	2 mg.	(vitamin K analog)	2 mg.

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BEFORE a single production step begins, measurements are taken, individual flesh and contour features noted. No effort is spared to give the amputee a leg as individual as men and machines can build.

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AVAILABLE AT AUTHORIZED FACILITIES IN THE FOLLOWING CITIES:

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NOVOCAIN "most frequently used for subarachnoid block as well as for other forms of regional analgesia . . ."*

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- **REGIONAL**
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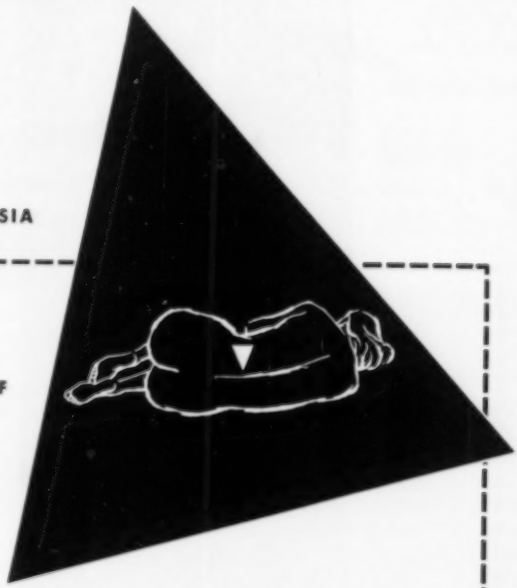

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Safely and successfully employed in millions of cases . . .

*Bonica, J. J.: The Management of Pain, Philadelphia, Lea & Febiger, 1953, p. 475.

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For spinal anesthesia:

Novocain crystals in ceramic imprinted ampuls, each containing 50 mg., 100 mg., 120 mg., 150 mg., 200 mg. and 300 mg. Novocain solution 10 per cent, ampuls of 2 cc. (200 mg.).

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"preventive geriatrics may hope to be most effective,"† since geriatric disability originates in these years. "Mediatric"* will help forestall atrophic changes due to waning sex hormone function and faulty nutrition.

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STEROIDS . . . to counteract declining sex hormone function

NUTRITIONAL SUPPLEMENTS . . . to meet the needs of the aging patient

A MILD ANTIDEPRESSANT . . . to promote a brighter mental outlook

Average dosage, 1 capsule or 3 teaspoonfuls of liquid, daily.

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†Scieglitz, E. J.: Geriatric Medicine, ed. 3, Philadelphia, J. B. Lippincott Company, 1954, p. 21.

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tables and tools

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ROGER ANDERSON FRACTURE AND SURGICAL TABLES offer exclusive suspension at the iliac crests and at the upper chest region. Since the patient's thorax and abdomen are unobstructed, he is able to breathe normally and blood loss is held to a minimum.

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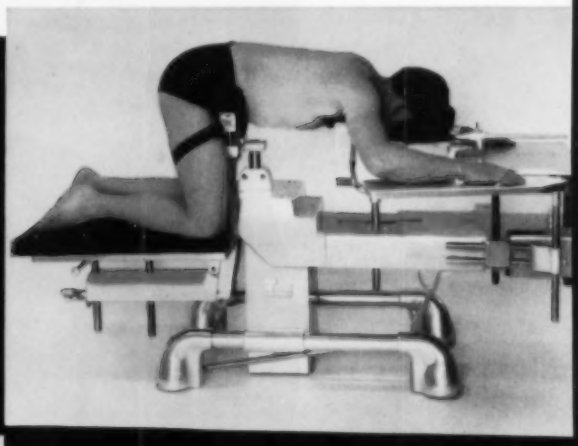

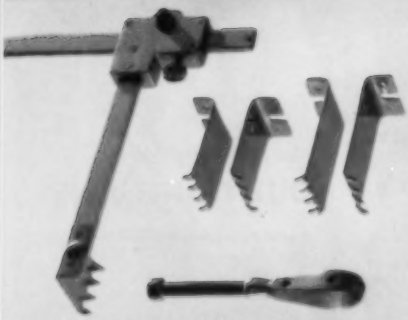

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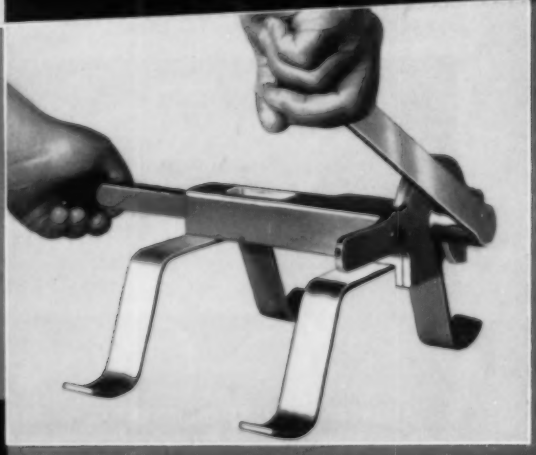

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by Orthopedic

Here's **ASSURED SAFETY** in a saw that both oscillates and rotates!

At last here's a fully explosion-proof surgical saw with foot control that retains all the advantages of oscillation and rotation.

- Fully conforms to safety requirements for Class 1, Group C, Hazardous Locations.
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- All blades, attachments and accessories used with the original Bishop Orthopedic Electric Bone Saw are interchangeable with this new explosion-proof unit.

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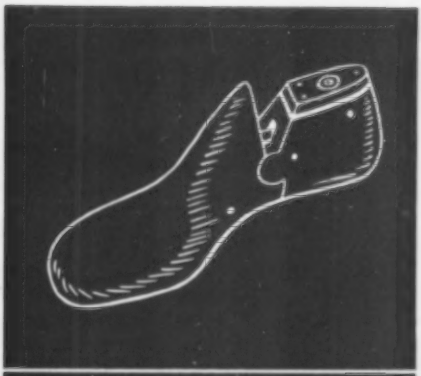

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The Orthopedist knows that the last is of supreme importance in shoemaking. For the shape of the last determines the shape of the shoe. Selby Junior Arch Preserver Shoes are built on lasts designed to meet the special needs of infants and children.

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When you recommend shoes for infants and children, please remember—

Selby Juniors are the only *genuine* Arch Preserver Shoes for children.

The only genuine Arch Preserver Shoes for children

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The Selby Shoe Company
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MORE THAN THREE QUARTERS OF A CENTURY OF FINE SHOEMAKING

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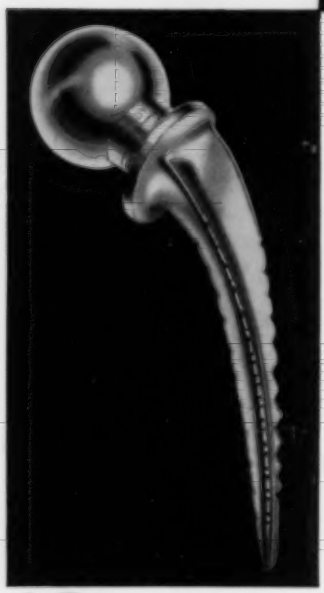

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This new hip prosthesis set reflects important improvements over preceding units. Ball portion, or head, and washer are detachable from stem, or nail. Allows different sizes of femoral heads to be fitted without removing the entire unit. Ball portion is hollowed out, fitting over the stem portion, which allows movement of the ball even after it has become frozen in the socket. Can be used with or without removable washer, which affords greater or less length, whichever is needed. Collar on stem enables weight to bear on femoral neck. Stem is available in two sizes, large and medium. Generally requires smaller canal, meaning less reaming, than other hip prosthesis units. Stem fins have serrated edges, which assure firm implanting. Entire unit is made of polished SMO Stainless Steel, carefully tested for imperfections, including the ZYGLO-PENTREX test method in our Magnaflux Certified Laboratory. Application technique is same as on any stem portion hip prosthesis. No. 618A, complete with stem, ball, and washer (specify diameter of ball, 1⅝", 1¾", or 1⅞"; and whether medium or large stem).

• *Plus* NEW ONE PIECE MODIFIED SCUDERI HIP PROSTHESIS

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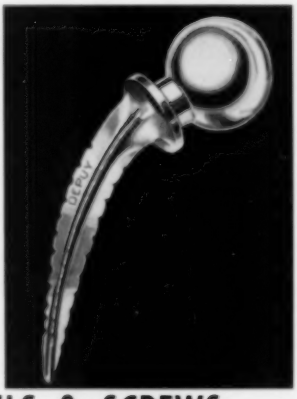

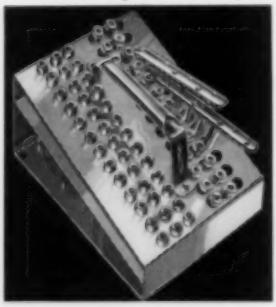

• *And* NEW STERILIZING RACK FOR HIP NAILS & SCREWS

A new sterilizing rack of advanced design, which prevents damage to nails and screws during autoclaving and storage. Quickly loaded. Will handle several dozen Smith-Petersen Nails, Jewett Nails, Lorenzo Screws, etc. Design is such that nails and screws cannot fall from rack in transit. Constructed of polished stainless steel. No. 646, (Less nails and screws). *WRITE FOR COMPLETE CATALOG!*

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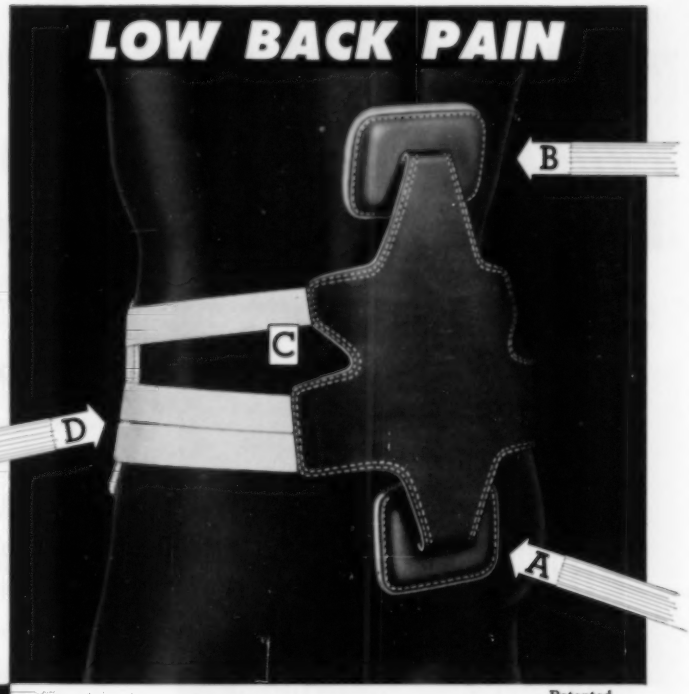
Announcing a New Principle of Relief with the Bell Posture Bridge by TRUFORM



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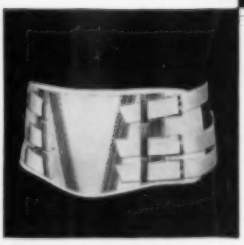

Eases facet impingement in the lumbo-sacral area by means of entirely unique 3-point pressure. Observe in the photo these key features:

Exerts Positive Forward Thrust to tilt the pelvis, by direct contact of the lower pressure pad with the posterior surface of the sacrum. A

Corrects Posture Defect, even excessive lordotic lumbar curvature . . . with the upper pressure pad acting as a fulcrum. B

C *Makes No Other Contact* along the back, between the Bridge's two "piers" . . . there is no interference with the positive pressure of the two pads.

D *Applies Controlled Counter-Pressure* by means of the tightly-pulled straps.

"*Seeing Is Believing*" . . . so welcome the Truform fitter in your city, Doctor, when he calls to show you this new Bell Posture Bridge. Only by actually examining and applying this unique support can you fully appreciate its perfect adaptability to the relief of low back pain. Over 500 patients . . . with and without sciatic involvement . . . have already proven the Bell Posture Bridge during its development and clinical evaluation.

As with all Truform Anatomical Supports, this Bell Posture Bridge is

"Available Only from Your Ethical Appliance Dealer"

Write for "Truform Red Book," the fully illustrated reference catalog of Anatomically Correct Surgical Supports and Surgical Hosiery.

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CHICK-LEINBACH
crib fracture set

. . . for all types of child tractions

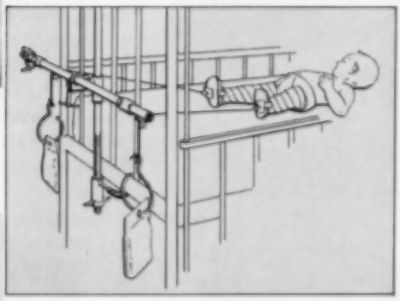
A complete children's fracture frame to take all type tractions on a crib. It fits any crib . . . metal or wood . . . causes no damage to the crib. It's economical! It's easy to store! It's simple to use!

ABOVE and **BELOW**—the Crib Fracture Set in use for Bryant's traction

AT RIGHT—the Crib Fracture Set in use for double Buck's extension

FEATURES

- fast assembly
- all angles of traction
- swivel jointed pulleys
- interchangeable parts
- light weight
- neat appearance
- few loose parts



The Crib Fracture Set can also be used for single Buck's and Cervical tractions.

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Manufacturers and Distributors of Hospital Orthopaedic and Fracture Equipment

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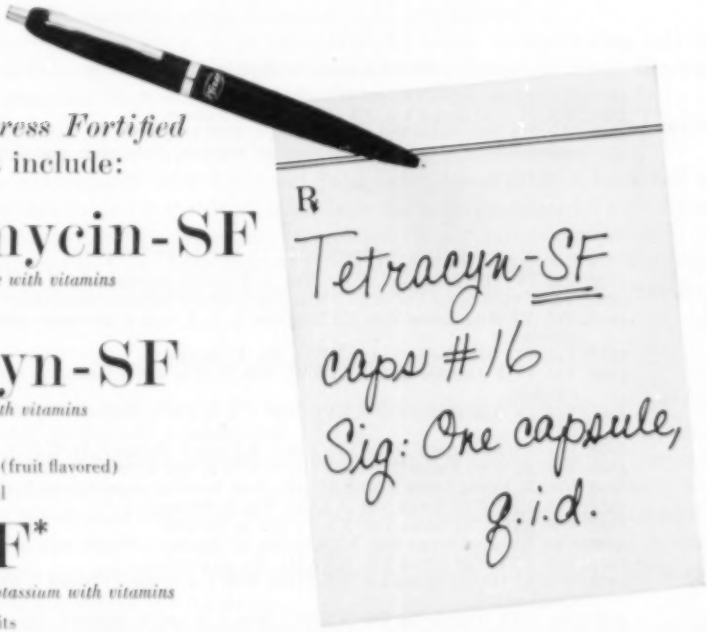

antibiotics *Stress Fortified* with vitamins include:

®Terramycin-SF

Brand of oxytetracycline with vitamins

CAPSULES 250 mg.

®Tetracyn-SF

Brand of tetracycline with vitamins

CAPSULES 250 mg.

ORAL SUSPENSION (fruit flavored) 125 mg./5 cc. teaspoonful

Pen-SF*

Brand of penicillin G potassium with vitamins

CAPSULES 200,000 units

The minimum daily dose of each antibiotic *(1 Gm. of Terramycin or Tetracyn, or 600,000 units of penicillin)* **Stress Fortifies the patient** *with the stress vitamin formula* **recommended by the National Research Council:**

Ascorbic acid, U.S.P.	300 mg.	Calcium pantothenate	20 mg.
Thiamine mononitrate	10 mg.	Vitamin B_{12} activity	4 mcg.
Riboflavin	10 mg.	Folic acid	1.5 mg.
Niacinamide	100 mg.	Menadione	
Pyridoxine hydrochloride	2 mg.	(vitamin K analog)	2 mg.

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DIAGNOSIS OF ORTHOPAEDIC LESIONS BY ASPIRATION BIOPSY

Results of 1,061 Punctures *

BY CARLOS E. OTTOLENGHI, M.D., BUENOS AIRES, ARGENTINA

The diagnosis of orthopaedic osteo-articular lesions is based upon three principal factors: (1) clinical examination; (2) roentgenographic examination; and (3) laboratory examination (pathological, bacteriological, chemical, and histochemical).

In order to ascertain the nature of an osteo-articular lesion in which diagnosis is doubtful clinically and roentgenographically, it is necessary to examine the lesion directly and it is for this reason that we favor biopsy, whether open or by aspiration.

In this paper we shall treat of the latter and discuss the results of our experience with 1,061 aspirations. These patients have been followed long enough for evaluation.

The author, in collaboration with Valls and Schajowicz, has written a book and a number of papers on this subject[35, 36, 37, 39]. It is not believed to be necessary to review the history of aspiration biopsy, but it is only just to mention the outstanding importance of the work on this subject which has been done at the Memorial Hospital in New York by clinicians, surgeons, and pathologists, such as Martin, Ellis, Sharp, Stewart, Snyder, Coley, and others.

ADVANTAGES OF ASPIRATION BIOPSY

1. *The method is simple*, and, except for special regions such as the spine, the instruments required are not technically complicated.

2. *The patient is not submitted to any risk:* If the technique is correctly carried out, no local complications from the puncture or from infection of the needle tract are observed. We have carried out histological studies of the needle tract without finding any abnormality. With reference to the dissemination of neoplastic lesions, we have no reason to impute such dissemination to aspiration biopsy, nor have we observed any new foci in inflammatory lesions as a result of the puncture.

3. As the aspiration needle penetrates the lesion, aspiration can be carried out at various points, so that there is a better possibility of making a correct diagnosis (Figs. 1-A and 1-B).

4. By aspiration deep areas of the skeleton can be reached, which would otherwise be accessible only by a major surgical operation (Fig. 2). Such procedures, if undertaken only for diagnosis, would be unacceptable to patients.

5. Because of the simplicity of the method, patients accept aspiration biopsy and offer no objection if it is necessary to repeat the procedure. In fifty-six of our cases we have repeated the aspiration procedure.

6. In the great majority of cases the method can be applied to out-patients, thus saving the patient both time and money.

* Read at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 27, 1954.

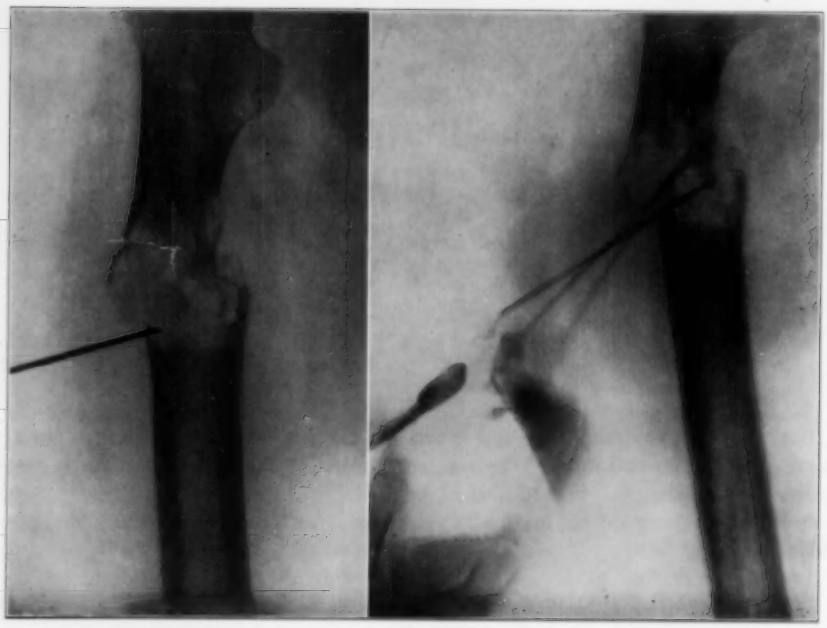

FIG. 1-A FIG. 1-B

Fig. 1-A: Case 1. A patient, eighty-two years old, with a pathological fracture of the femur. The needle is seen to reach the lesion.

Fig. 1-B: Aspiration was carried out at several points. The diagnosis was metastatic carcinoma.

7. Once the technique has been mastered, it can be applied by non-specialists and can therefore be carried out by doctors whose practice is at a distance from the larger medical centers; the aspirated material can then be sent to a pathologist.

8. Aspiration biopsy offers no disadvantage to the patient who must later submit to an operation.

9. Aspiration biopsy does not interfere with roentgen therapy if this treatment is later found necessary, since the skin lesion from the slight puncture with a scalpel is minor.

10. Aspiration biopsy does not exclude open biopsy.

DISADVANTAGES OF ASPIRATION BIOPSY

1. *The greatest drawback is the small amount of the material withdrawn.* In a number of cases the amount of aspirated material is very small and the puncture must be repeated. The majority of our negative biopsies were due to the insufficiency of the material aspirated. This drawback may be due to two fundamental causes:

a. That the lesion is sclerotic and that the needle cannot penetrate to any depth.

b. That the wrong technique has been used. This is generally due to inexperience, so that the puncture is carried out without the necessary roentgenographic control, or is made in superficial or peripheral areas of the lesion.

2. It is argued that aspiration biopsy is a blind method and that it is impossible to know precisely where the needle penetrates. This objection can be ruled out, since the location is determined by x-ray and, when some experience has been acquired, the point or points at which the needle lies can be ascertained with great precision. Moreover, it is of interest to know the greater or lesser resistance offered by the tissues which are being penetrated, particularly when bone is reached. After he has made a number of punctures, the surgeon acquires a special tactile sensibility which enables him to pass on valuable information to the pathologist.

3. The needle may damage some important organs. When the correct technique is used, this danger is non-existent. In 1,061 punctures this has never occurred.

4. It is argued that the tissues to be examined may be structurally altered by aspiration biopsy. This has not occurred in our experience since we use needles which, although of large caliber, do not damage the structure. On the other hand, with the use of trephine needles employed by some, the pathologist may find it more difficult to make a diagnosis because of alterations in the tissues from mechanical causes[1, 15, 29, 34].

5. It has been pointed out that in many cases aspiration biopsy produces results which are inconclusive because based on insufficient evidence. It must be stated that anatomopathological examination can be effected both on smear and on embedding. Some writers who have reported on this method have made use of the cytological method only. In that case it is quite probable that the results would be uncertain. Whenever possible a cytological study of the material is effected on smear, but we reserve the greater portion for embedding in paraffin in order to carry out histological studies of the lesion. A precise cytological diagnosis is difficult, since the structure is not studied. This means that, when the cells are not very characteristic, they do not yield sufficient evidence to establish a classification. This objection is valid, since in spite of having aspirated sufficient material, the pathologist is sometimes unable correctly to classify the lesion and open biopsy must be employed.

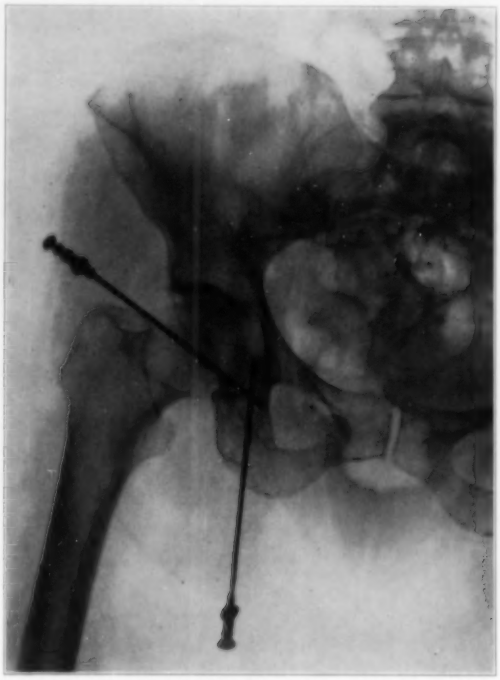

FIG. 2

Case 2. A patient, seventy-eight years old, with an osteolytic lesion of the right acetabular fossa. The two needles are shown in position; the medial needle reaches the lesion. The pathological diagnosis was non-specific inflammatory process.

6. In none of our cases has hemorrhage occurred, with the single exception of a case of generalized plasmacytoma in which a hematoma was produced in the needle tract of a vertebral puncture.

7. It has been argued that aspiration biopsy may provoke the development of neoplastic and infectious lesions, that is to say, a local contamination. As has been stated, this has not occurred in our series.

8. *The cooperation of a competent anatomopathologist is required.* This objection is valid, but the same might be said of any operation carried out by an inexperienced surgeon. The small quantity of the material obtained calls for a skill which not every pathologist can boast of. The pathologist should be a specialist in bone pathology.

Our case material is submitted to the pathologist only after he has been informed of the clinical setting, has examined the roentgenograms with us, and has been present at the aspiration. He can thus state whether the material aspirated is sufficient or whether further aspirations must be made and, if so, in which direction. It is our custom to talk over the diagnosis with the pathologists and we require them to be present at meetings at which clinical diagnoses are discussed.

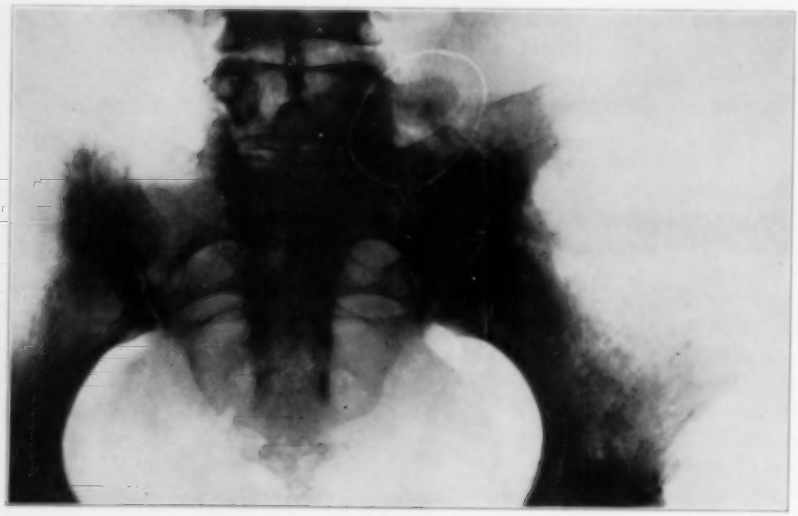

FIG. 3-A

Case 3. Osteogenic sarcoma of the transverse process of the fifth lumbar vertebra.

SOME TECHNICAL CONSIDERATIONS

It is not intended here to enter into the details of aspiration-biopsy technique. We should merely like to mention some points of particular interest, so that the maximum advantage may be derived from the method.

We follow approximately the technique employed in Memorial Hospital of New York.

1. Syringes with metal sleeves or at least metal tips should be used; the tip of the common glass syringe often breaks off when the suction movement is effected.

2. Needles should be two millimeters in diameter[8], very acutely beveled at the point, and well sharpened.

3. The needles should be fixed to the syringe as hermetically as possible.

4. Puncture of the skin should be made with the point of a scalpel.

5. In sclerotic lesions there is a high proportion of failures. If the bone offers great resistance to the needle, it is necessary to make a perforation with a drill; even so the material aspirated is often insufficient.

6. When the site has been reached, the needle should be pointed in several directions (Fig. 1-B).

7. Aspiration is made after a vacuum has been produced in the syringe by withdrawal of the piston by one centimeter; this produces the suction.

COMMENTS AND DISCUSSION

Aspiration biopsy is indicated in all cases of questionable diagnosis; it is unnecessary when diagnosis can be made by clinical and roentgenographic examination.

Aspiration biopsy should be carried out before any treatment, particularly roentgen therapy, is begun, since the application of roentgen rays may alter the histological structure and may make it difficult to classify lesions which might easily have been diagnosed before treatment.

In the measure that we have practised a greater number of aspirations and have obtained the cooperation of skilled pathologists, we have achieved more precise diagnoses and clearer classification, particularly in malignant tumors.

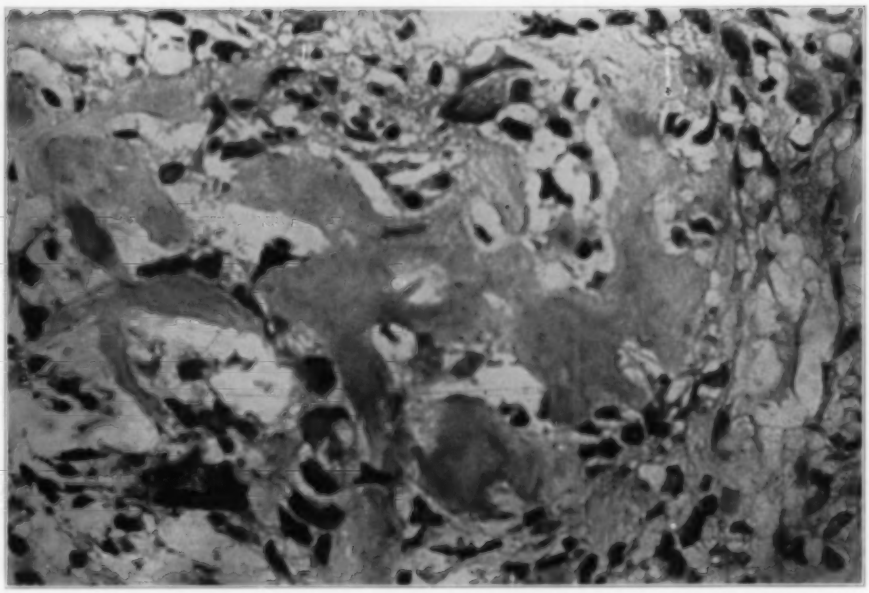

FIG. 3-B

High-power photomicrograph of a section from the lesion, showing numerous irregular, newly formed osteoid trabeculae separated by atypical osteoblastic cells.

We set great store by differentiating between primary and metastatic tumors, and for this reason we are not satisfied to establish a diagnosis of malignant tumor only; we insist that the pathologist should establish, wherever possible, such a precise diagnosis as to enable us to apply the most favorable treatment for each case.

The aspirated material enables the pathologist not only to follow the usual technical procedures but also to employ special methods of staining, such as silver impregnation for reticulin fibers, which is of importance in the diagnosis of reticulum-cell sarcoma.

In spite of the small amount of the material obtained, the pathologist can carry out histochemical studies. He may, for instance, make glycogen and alkaline phosphatase determinations; the former may be altered in Ewing's sarcoma, the latter in Paget's disease.

It is most important that, when the presence of inflammatory disease is suspected, a part of the material collected should be set apart for bacteriological examination. This is true especially of tuberculous lesions in which the pathological changes may be doubtful, while guinea-pig inoculation results in positive diagnosis.

RESULTS

Of 1,061 aspirations carried out upon 998 patients, the results were classified as positive, doubtful, and negative. A result is considered *positive* when the diagnosis can be established; *doubtful* when the diagnosis cannot be confirmed and must be verified by some other means; *negative* when the diagnosis cannot be made.

Results obtained in 1,061 punctures were as follows:

	No.	*Per cent.*
Positive	895	84.35
Doubtful	45	4.25
Negative	121	11.40

In forty-nine cases there were repeat punctures for the following reasons: (1) because insufficient material was obtained from the first puncture; (2) to confirm a diagnosis;

(3) because the lesions had several foci and punctures were made in several bones. Of these forty-nine repeat aspirations, twenty-four were positive, seven were doubtful, and eighteen were negative.

In seven other cases three punctures each were made, with the following results: twelve negative, four doubtful, and five positive.

Punctures were made in nearly all of the bones of the skeleton, with the exception of those at the base of the skull and the vertebrae between the first and the tenth thoracic.

FIG. 4-A

The number of punctures according to location are as follows:

Vertebral bodies	204
Femur	175
Pelvis	141
Hip joint	67
Humerus	65

The other punctures were made in various other bones of the skeleton, but it is not considered necessary to mention them in detail.

In the 895 punctures in which the results were positive, diagnosis was confirmed in 871 by open biopsy, by surgical exposure of the

Fig. 4-A: Case 4. A female, seventy-two years old, with fibrosarcoma of the lower third of the femur. A differential diagnosis between primary and metastatic tumor had to be established.

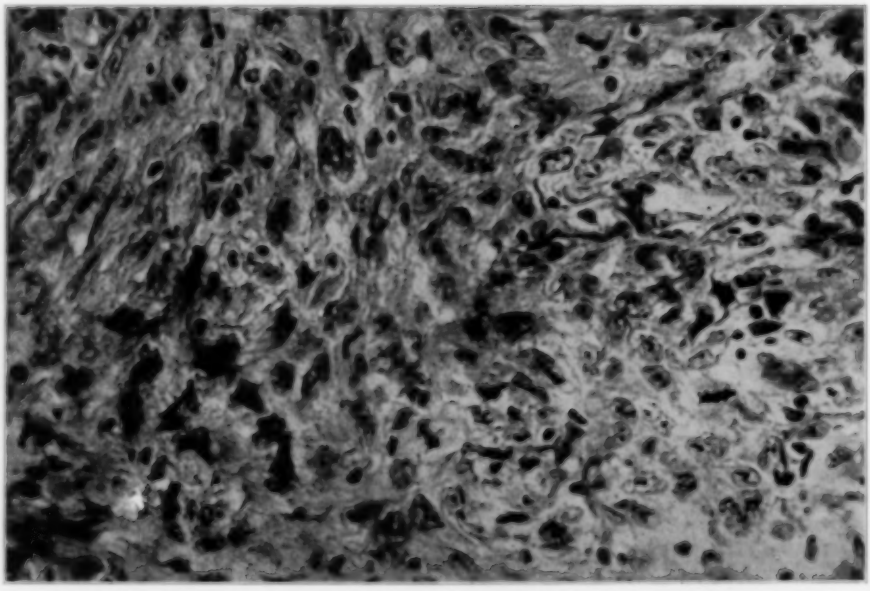

FIG. 4-B

Fibrosarcoma. The fibroblastic elements show atypia and nuclear hyperchromatism.

lesion, or by the clinical course (Table I). It should be remembered that in twenty-four of these cases there were repeat punctures with positive results.

The greatest number of diagnoses in our series were for malignant tumors.

Osteogenic Sarcoma: Forty Cases

Thirty-eight cases were classified as osteogenic sarcoma by aspiration biopsy (Figs. 3-A and 3-B) and the diagnosis was confirmed at operation. Amputation was performed in most of these cases.

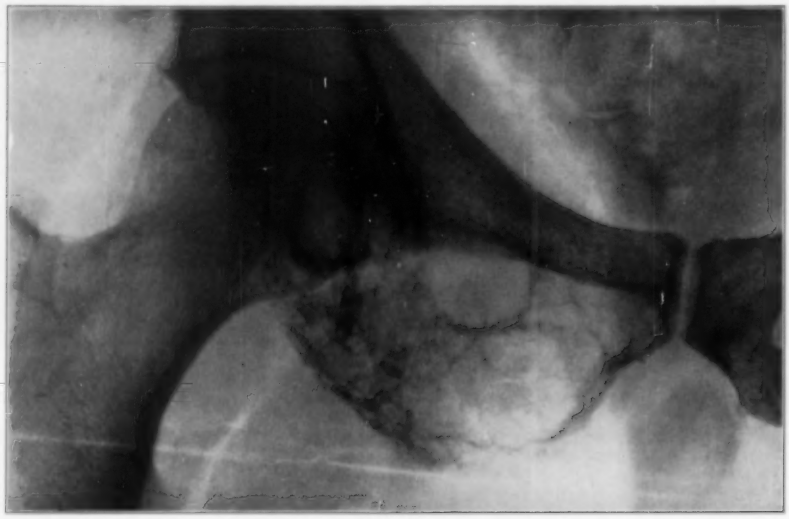

FIG. 5-A

Case 5. A male, forty-two years old, with a myeloma of the ischium.

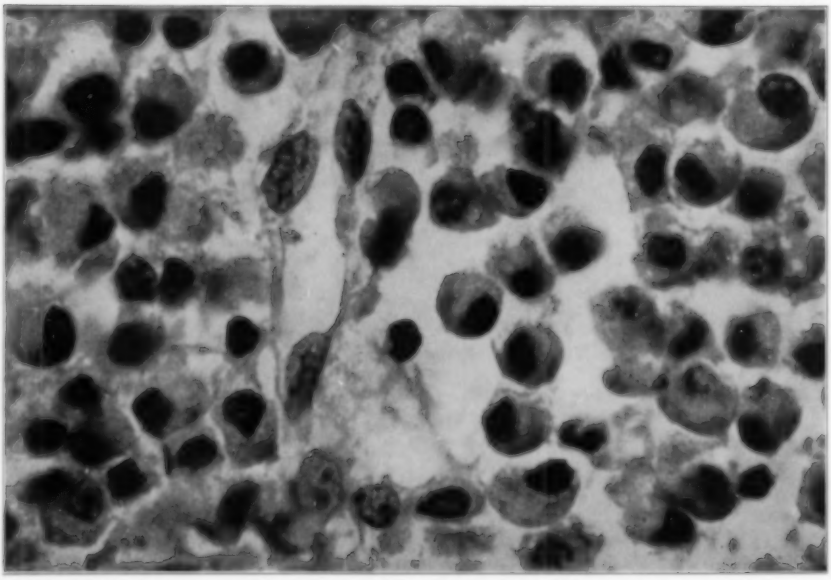

FIG. 5-B

Photomicrograph of a section from the lesion shows the bone marrow invaded by abundant plasmacytic cells with eccentric nuclei and basophilic cytoplasm (plasmacytic myeloma).

FIG. 6-A

FIG. 6-B

Fig. 6-A: Case 6. A male, sixty-two years old, with a pathological fracture of the first lumbar vertebra body.

Fig. 6-B: The roentgenogram showed flattening of the first lumbar vertebra. A diagnosis of myeloma was made on the basis of aspiration biopsy.

In cases of metastasis progress of the disease resulted in death of the patient. In one case only, one of our earliest punctures, a diagnosis of osteogenic sarcoma was made, but open biopsy proved the lesion to be osteomyelitis. In one case the biopsy was negative; the presence of giant cells and zones of osteoid tissue difficult to classify were observed; in this

FIG. 7-A

Case 7. A female, fifteen years old, with Ewing's sarcoma of the sacro-iliac joint. This case had been diagnosed as tuberculosis and had been treated accordingly.

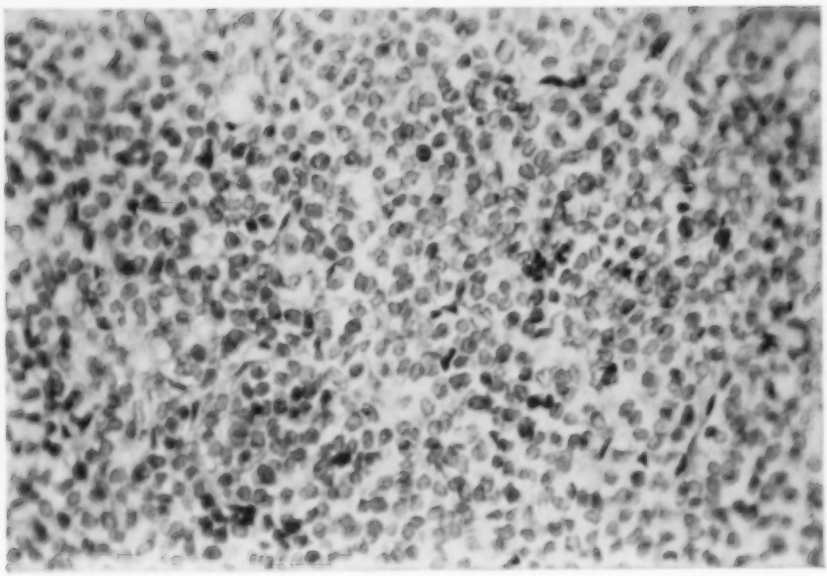

FIG. 7-B

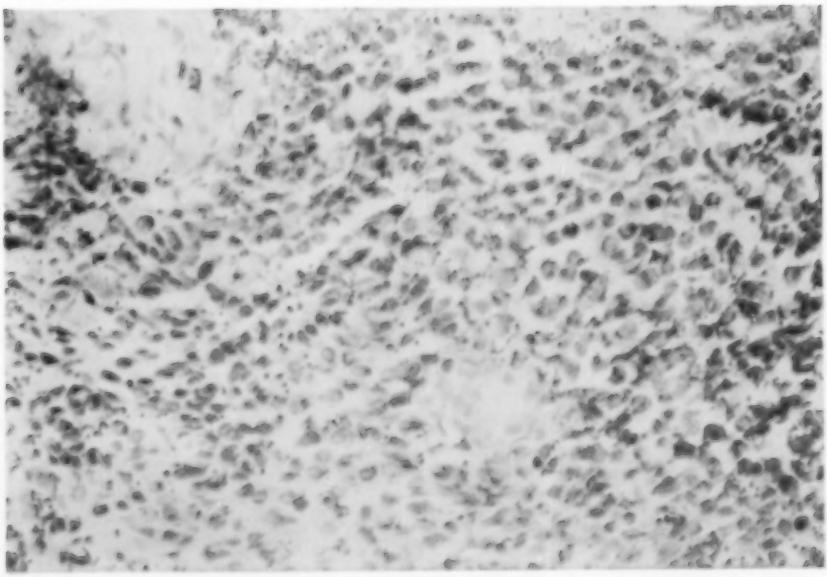

FIG. 7-C

Fig. 7-B: Section from the tumor, consisting of round cells. Cytoplasm is not visible with the staining technique used in this section (hematoxylin-eosin). Differential diagnosis between Ewing's sarcoma and reticulum-cell sarcoma had to be established.

Fig. 7-C: Specimen from the same case, stained with the McManus technique for mucoproteins. This technique brings out the numerous red granules in the cytoplasm of the tumor cells due to glycogen. In reticulum-cell sarcoma this type of granule is absent.[25, 29]

TABLE I

SUMMARY OF POSITIVE DIAGNOSES*

Osteogenic sarcoma	38
Fibrosarcoma	10
Chondrosarcoma	13
Myeloma	52
Ewing's sarcoma and reticulum-cell sarcoma	38
Metastatic carcinoma	254
Miscellaneous malignant tumors	23
Chondroma	33
Epiphyseal chondroblastoma	7
Fibroma, myxoma, lipoma, and related tumors	12
Osteoma	2
Giant-cell tumor	33
Bone cyst, solitary	12
Fibrous dysplasia	25
Histiocytic granuloma	29
Paget's disease	25
Osteoporosis	34
Gaucher's disease	2
Hodgkin's disease	2
Leukaemia	3
Tuberculosis	56
Syphilis	5
Hydatidosis	9
Osteomyelitis	43
Unspecified chronic inflammatory disease	74
Arthritis deformans (osteo-arthritis)	15
Miscellaneous	22
Total	871

* These diagnoses were confirmed by open biopsy, by surgical exposure of the lesion, or by the clinical course.

case open biopsy was positive. In one case osteogenic melanosarcoma was diagnosed; in another it was impossible to establish whether the growth was an osteogenic sarcoma or an angiosarcoma; and in one case biopsy was doubtful.

Fibrosarcoma: Eleven Cases

In ten cases diagnosis by aspiration biopsy was positive (Figs. 4-A and 4-B); it was negative in one case, in which diagnosis was established by open biopsy. In three patients the tumors occurred in soft parts without bone lesions. In some instances differential diagnosis between cellular fibroma and fibrosarcoma of low-grade malignancy is difficult.

Chondrosarcoma: Fifteen Cases

In thirteen cases diagnosis by aspiration biopsy was positive; in two cases it was doubtful but was later confirmed by open biopsy. Two cases of epiphyseal chondroblastoma (benign) [38] were originally classified as Geschickter and Copeland's chondroblastic sarcoma, but later revision in the light of Jaffe and Lichtenstein's work [10] resulted in correct classification.

Myeloma: Fifty-three Cases

In fifty-two cases diagnosis was positive (Figs. 5-A and 5-B). In one case a repeat puncture had to be made, which proved to be positive. Cytological examination of the smear allows of quick classification which can be confirmed by paraffin sections. Laboratory tests help to establish the diagnosis. In order to determine the extent of the disease when there is uncertainty, sternal aspiration is made.

FIG. 8-A

Case 8. A female, forty-two years old, with metastatic carcinoma of the ischium. Note the similarity of this roentgenogram to that in Case 5 (Fig. 5-A).

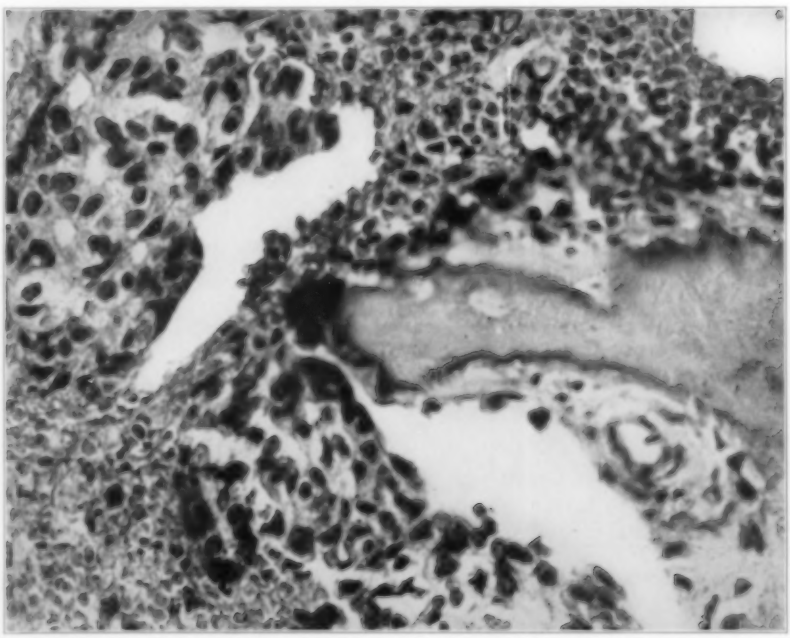

FIG. 8-B

Photomicrograph of a specimen from the same case, showing epithelial formations surrounding a bone trabecula. The diagnosis was metastatic adenocarcinoma.

Diagnosis of this lesion by aspiration biopsy is relatively easy for an experienced pathologist. It is interesting to note the frequency with which myeloma is located in the spine; in twenty-two instances diagnosis was established by puncture of the vertebral bodies (Figs. 6-A and 6-B).

Ewing's Sarcoma: Twenty-one Cases, and *Reticulum-Cell Sarcoma:* Seventeen Cases

We include in the group of reticulum-cell sarcomata the primary lesions in bone, as

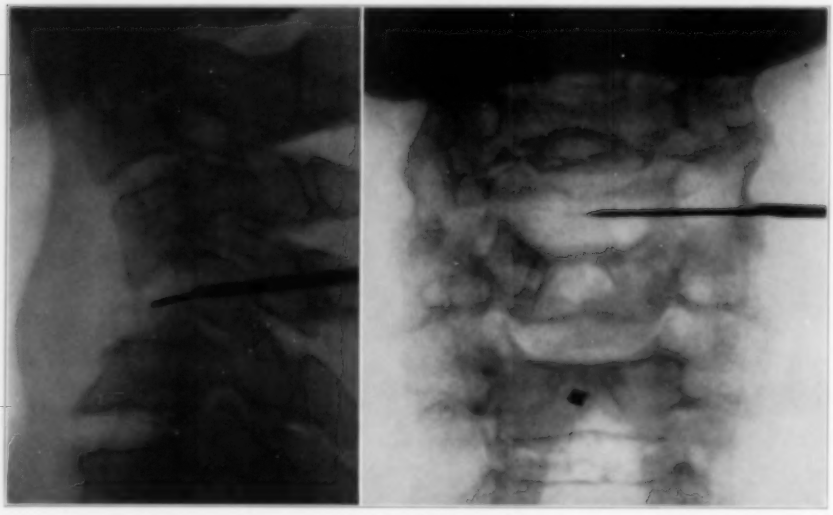

FIG. 9-A

Case 9. The roentgenograms showed an osteolytic lesion of the body of the fourth cervical vertebra.

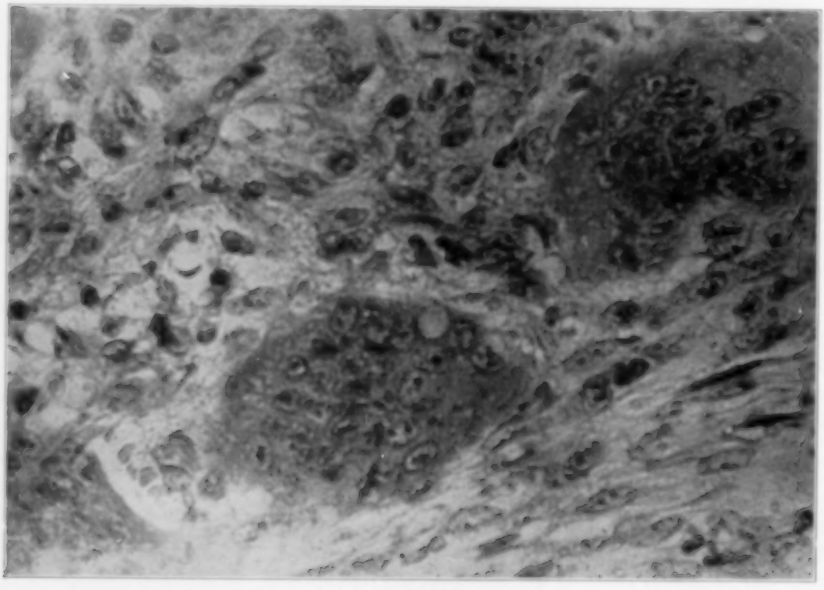

FIG. 9-B

Photomicrograph, demonstrating multinuclear giant cells separated by a fibroblastic stroma which shows atypical nuclear structure (aggressive type of giant-cell tumor).

FIG. 10-A

Case 10. A fifteen-year-old male with eosinophilic granuloma of the clavicle.

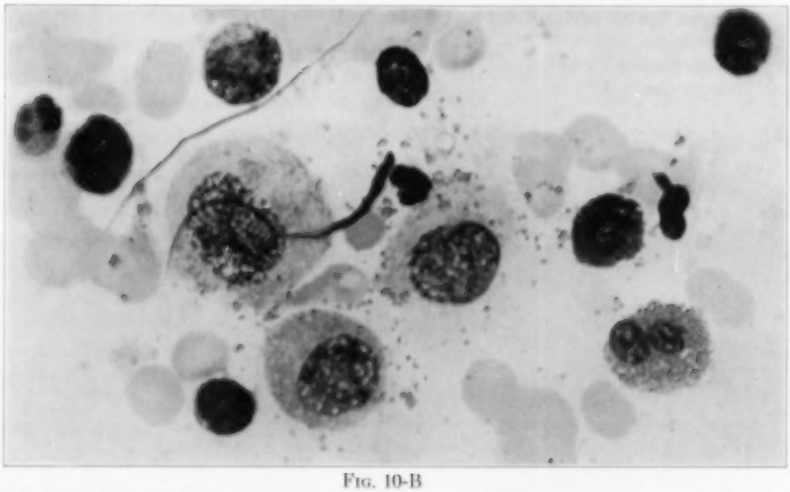

FIG. 10-B

Photomicrograph of smear, showing histiocytic elements with large nuclei and an increased number of eosinophilic cells.

well as those cases in which bone lesions form part of generalized lymphosarcomatosis or reticulosarcomatosis, or in which they are secondary to a lymph-gland lesion (secondary reticulosarcoma). Because of their identical structure, it is impossible to distinguish these types histologically.

Differential diagnosis of Ewing's sarcoma and reticulum-cell sarcoma is sometimes difficult by aspiration biopsy, but we wish to point out that there is the same difficulty with material obtained by open biopsy, although to a lesser degree, and it is generally necessary to carry out special silver impregnations of the reticulum fibers.

Schajowicz[26,29] recently described the presence of abundant granules of glycogen in the cytoplasm of the tumor cells of Ewing's sarcoma; these are absent in reticulum-cell sarcoma. This finding is very helpful in the differential diagnosis, as may be observed in Figures 7-A, 7-B, and 7-C. In one case the result of aspiration biopsy in this type of tumor was doubtful. In one case the original diagnosis was osteomyelitis of the femur. A second

puncture, carried out a year later upon the same site, proved the lesion to be a reticulum-cell sarcoma.

Metastatic Carcinoma: 266 Cases

These tumors constitute the largest group. Aspiration biopsy is not routine in our clinics when the clinical and roentgenographic findings are obvious, but in many instances metastasis appears before the site of the primary tumor is known (Case 8, Figs. 8-A and 8-B) and patients have even died before the site of the original tumor was determined.

Aspiration biopsy makes it possible to localize the original tumor in certain cases, as for instance in the hypernephromata, metastases of thyroid tumors, bronchogenic carcinomata, mucoid tumors of gastro-intestinal origin, and others.

In eleven cases aspiration biopsy only showed cells of a neoplastic type and a diagnosis of malignant tumor was established without our being able to classify the lesion correctly. In one case aspiration biopsy was negative for metastasis, but open biopsy was positive. In this group we have been able to diagnose by aspiration biopsy metastatic tumors which both clinically and roentgenographically had the appearance of primary tumors.

Benign Tumors: Eighty-eight Cases

Chondroma and osteochondroma	33
Epiphyseal chondroblastoma	7
Fibroma, lipoma, angioma, and neurinoma	12
Osteoma	2
Benign giant-cell tumor	22
Aggressive giant-cell tumor	12

Only the giant-cell tumors will be discussed in this group.

Giant-Cell Tumor: Thirty-four Cases

Schajowicz and Mondolfo have made an interesting study of these tumors and the former, in cooperation with Lustig, has obtained giant-cell cultures which show their origin and development *in vitro*.

FIG. 11-A

Case 12. A fifteen-year-old male. The roentgenogram showed a slight osteolytic lesion in the acetabulum.

Aspiration biopsy is very effective in this type of tumor not only in establishing the diagnosis, but also in many instances in determining the degree of aggressiveness; this was proved to be correct in twelve cases and doubtful in one. This factor is of major importance for therapeutic indications (Case 9, Figs. 9-A and 9-B).

We are able to differentiate with a high degree of certainty the xanthomatous variety of tumor, which we interpret as xanthomatous histiocytic granuloma and include in the group of histiocytic granulomata[28].

TABLE II

POSITIVE DIAGNOSES IN 171 ASPIRATION BIOPSIES OF THE SPINE

Metastatic carcinoma	68
Myeloma	22
Ewing's tumor	2
Reticulum-cell sarcoma	1
Giant-cell tumor	3
Angioma	1
Ependymoma	1
Tuberculosis	19
Osteomyelitis	11
Unspecified chronic inflammatory disease	17
Brucellosis	2
Echinococcosis	2
Osteoporosis	18
Paget's disease	4
Total	171

Differential diagnosis between the brown tumor of von Recklinghausen's disease and benign giant-cell tumor (Grade 1) may be difficult.

Dystrophic Diseases

Solitary Bone Cyst: Twelve Cases

Clinical and roentgenographic diagnosis of this lesion is generally easy to make. Aspiration biopsy permits diagnosis by exclusion of other diseases of the dystrophic type.

Fibrous Dysplasia and von Recklinghausen's Disease: Thirty Cases

In one case of fibrous dysplasia aspiration biopsy was negative. In four cases the

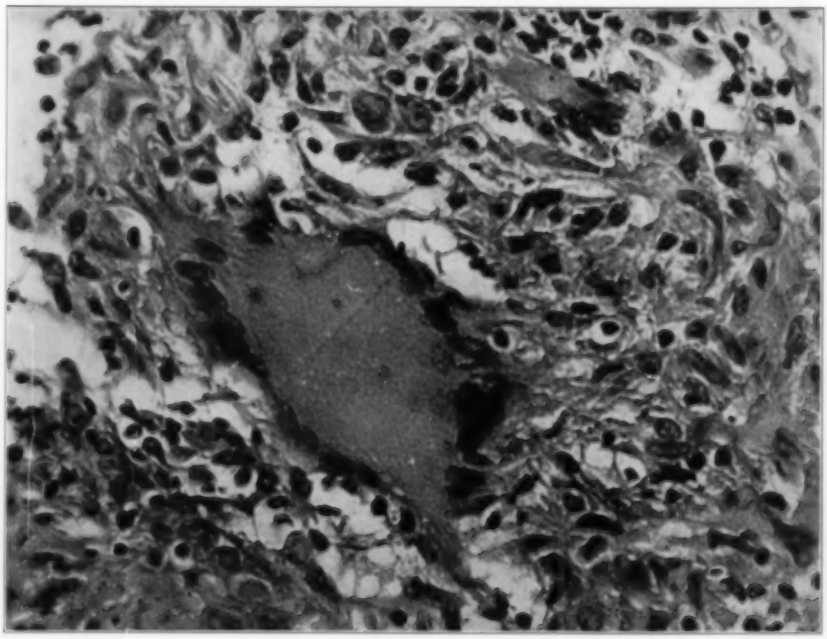

FIG. 11-B

The photomicrograph revealed typical Langhans' giant cells and epithelioid cells characteristic of tuberculosis. Guinea-pig inoculation was positive for tuberculosis.

FIG. 12-A

Case 13. A man, forty-six years old, with echinococcosis of the iliac bone.

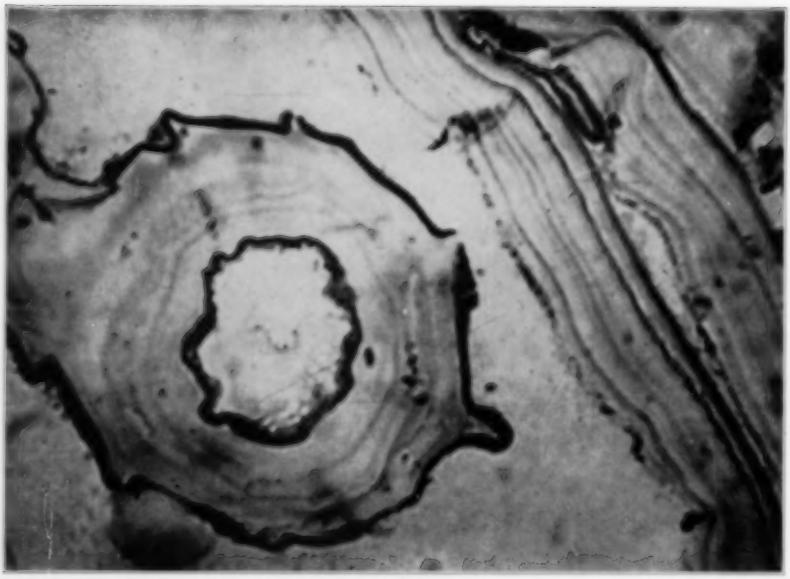

FIG. 12-B

Photomicrograph, showing a typical hydatid vesicle with its germinative (internal) and cuticular membrane.

diagnosis was doubtful and was confirmed surgically. In many of these cases histopathological examination showed newly formed bone trabeculae and fibrous transformation of the marrow, a frequent reaction in several diseases, including fibrous dysplasia. Diagnosis has been confirmed by surgical exposure of the lesion in most of these cases.

There were two cases of von Recklinghausen's disease.

Histiocytic Granuloma and Lipoidosis of Bone: Thirty-two Cases

We classify hyperplastic processes of the reticulo-endothelial elements of bone

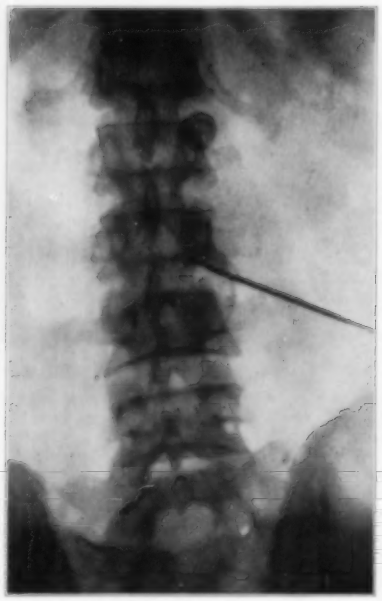

FIG. 13-A

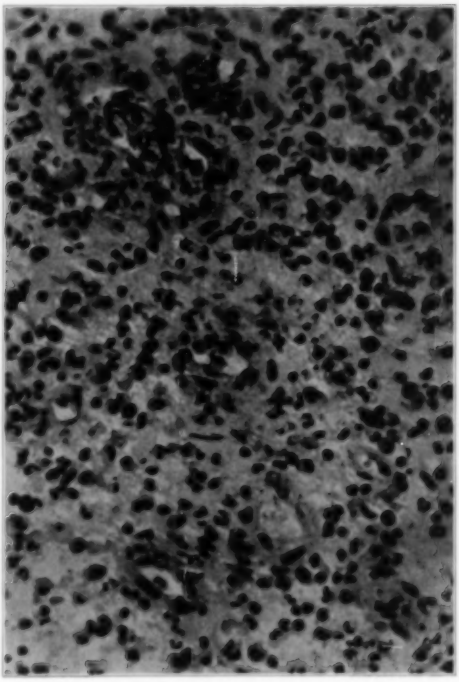

FIG. 13-B

Fig. 13-A: Case 14. The roentgenogram demonstrated an osteomyelitic process in the second and third lumbar vertebrae.

Fig. 13-B: The photomicrograph shows an inflammatory process with lymphocytic, plasmacytic, and leukocytic infiltration. The blood vessels are full of granulocytes. Cultures revealed abundant colonies of *Staphylococcus aureus*.

marrow under the denomination of hystiocytic granuloma.[28] We include in this group simple histiocytic granuloma, eosinophilic granuloma (Case 10, Figs. 10-A and 10-B), and histiocytic xanthomatous granuloma; the latter belong to the xanthomatous variety of giant-cell tumor or to the xanthoma of other writers and the non-osteogenic fibroma of Jaffe and Lichtenstein[11]. Histiocytic granuloma may appear either as a single or as a multiple lesion; the latter sometimes forms part of the syndrome of Schüller-Christian or Letterer-Siwe disease.

Of these patients eight had granulomata of the xanthomatous type; in three cases aspiration biopsy was negative and diagnosis was made from material obtained operatively. There were two cases of lipoidosis and two of Gaucher's disease.

Paget's Disease: Twenty-four Cases, and *Sarcomatous Degeneration:* Five Cases

Of twenty-four cases of Paget's disease, diagnosis was established in twenty. In four cases diagnosis was doubtful.

A difficulty which is sometimes met with in aspiration biopsy is that the bone may be sclerotic and a perforation must first be made to allow the needle to penetrate. Generally speaking, if the puncture site is carefully chosen, osteolytic zones are usually found which can be penetrated more easily. The "mosaic" structure which is characteristic in this disease obviates doubt, but when there is excessive proliferation of osteoid tissue, the diagnosis may be questionable.

In five cases sarcomatous degeneration of Paget's disease was diagnosed.

Osteoporosis: Thirty-four Cases

The majority of the patients with osteoporosis were senile: in twenty the condition

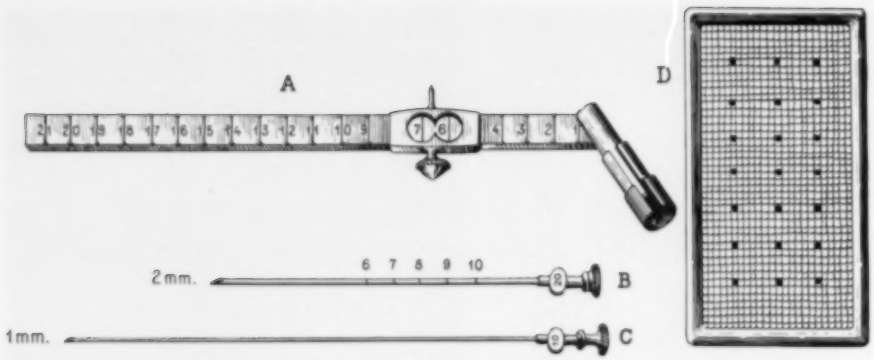

FIG. 14

A: Author's needle guide; *B:* Aspiration needle, twelve centimeters long, with a two-millimeter gauge, with markings from the sixth to the tenth centimeter; *C:* Exploring needle, eighteen centimeters long, with a one-millimeter gauge; *D:* Lined metal plate used to indicate the spot to be punctured

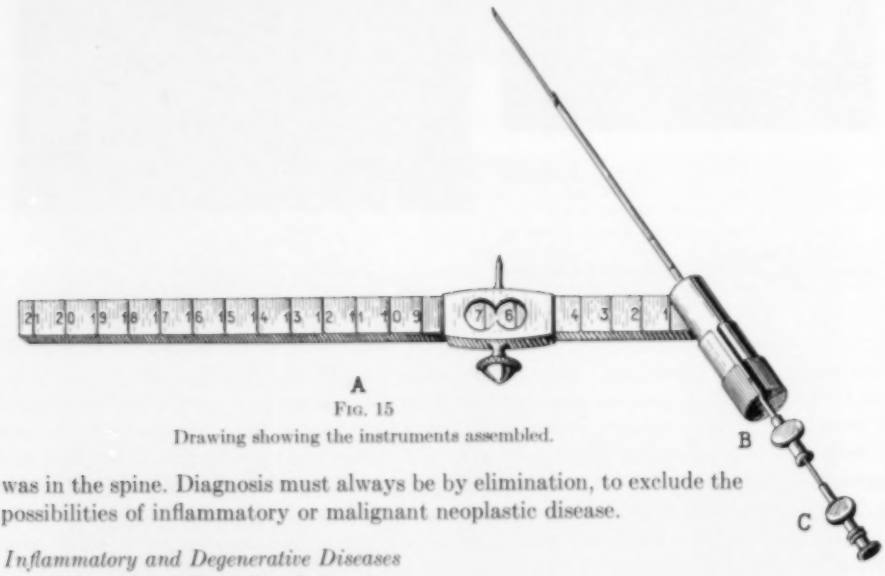

FIG. 15

Drawing showing the instruments assembled.

was in the spine. Diagnosis must always be by elimination, to exclude the possibilities of inflammatory or malignant neoplastic disease.

Inflammatory and Degenerative Diseases

Tuberculosis: Sixty-five Cases

Diagnoses were established by means of histological study (Case 12, Figs. 11-A and 11-B) and inoculation of guinea pigs.

We usually carry out complementary examinations, such as regional lymph-gland biopsy which we have practised since 1933[21], being the first to establish this means of diagnosis on a systematic basis to confirm the tuberculous nature of these lesions.

Twenty-one lesions were in the spine; diagnoses in all were positive, with the exception of one.

Of the forty-four patients in whom the lesion occurred in other locations, aspiration biopsy was negative in five, open and lymph-gland biopsy being negative. Diagnosis in three was doubtful and the lesions were proved to be tuberculous by other forms of diagnosis.

Syphilis: Seven Cases

In five cases histological examination proved definitely positive. In the other two it

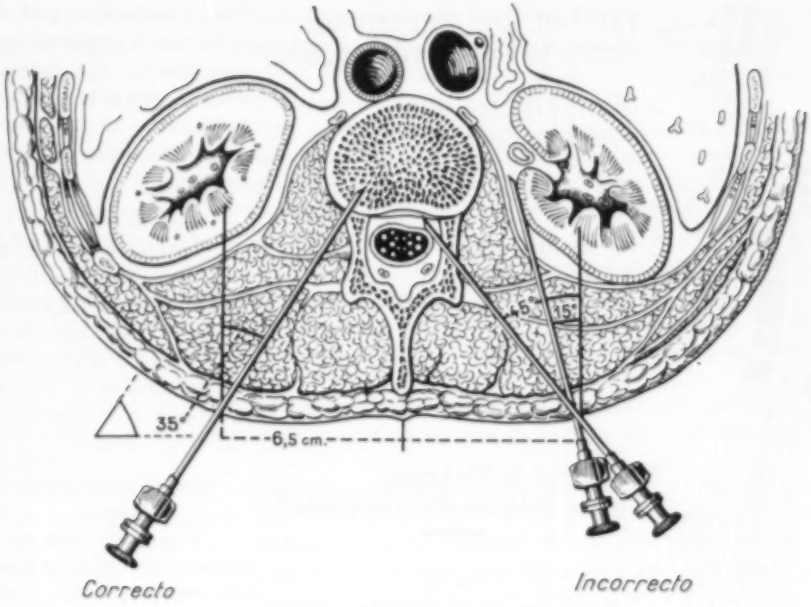

FIG. 16

Showing the correct (left) and incorrect (right) direction of the needles.

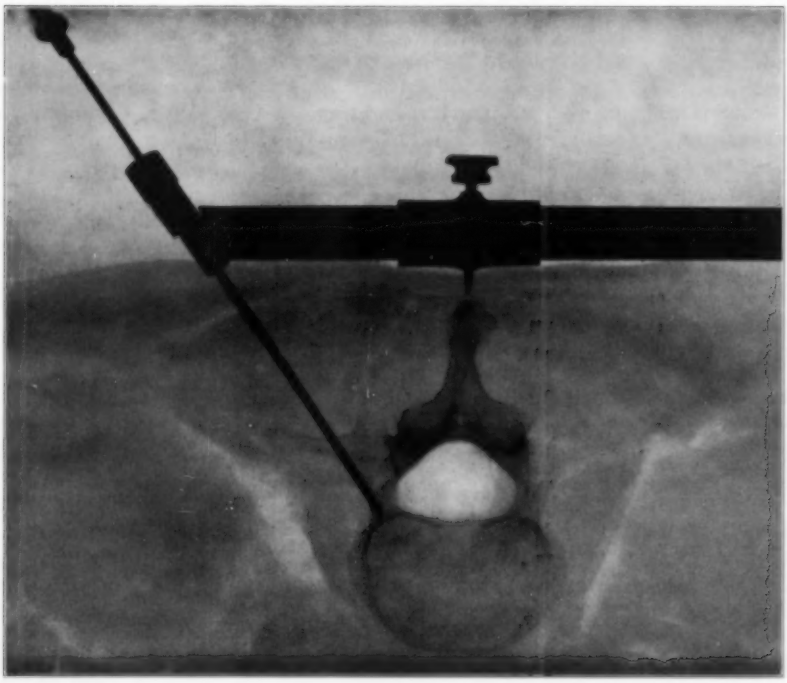

FIG. 17

Roentgenogram showing the guide in place, with the needle reaching the vertebral body.

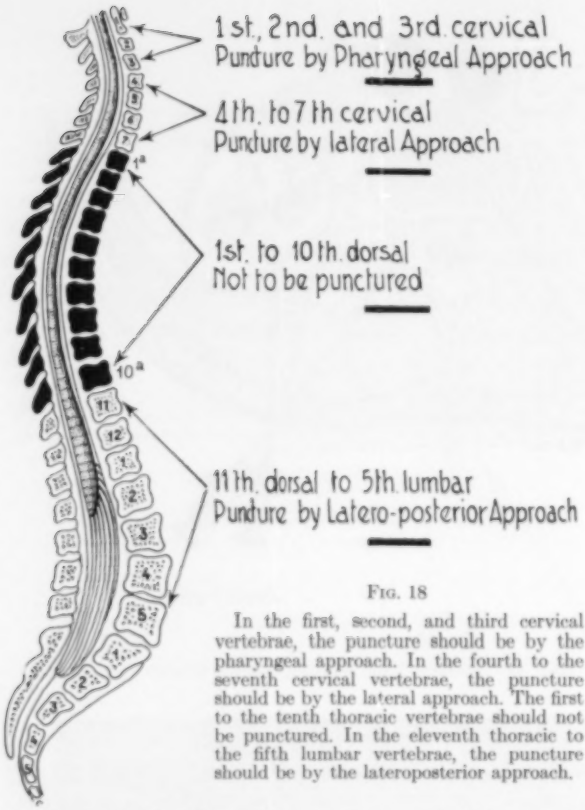
1st., 2nd. and 3rd. cervical
Puncture by Pharyngeal Approach
4th. to 7th cervical
Puncture by lateral Approach
1st. to 10th. dorsal
Not to be punctured
11th. dorsal to 5th. lumbar
Puncture by Latero-posterior Approach

FIG. 18

In the first, second, and third cervical vertebrae, the puncture should be by the pharyngeal approach. In the fourth to the seventh cervical vertebrae, the puncture should be by the lateral approach. The first to the tenth thoracic vertebrae should not be punctured. In the eleventh thoracic to the fifth lumbar vertebrae, the puncture should be by the lateroposterior approach.

was questionable and diagnosis was determined by the case history, the roentgenographic appearance of the lesions, and by the Wassermann and Kahn tests, which were positive.

Hydatidosis: Nine Cases

Diagnosis in all these cases was positive. In hydatidosis diagnosis is easily established by aspiration biopsy, because of the presence of membranes in the aspirated material (Case 13, Figs. 12-A and 12-B).

Osteomyelitis: Forty-three Cases

When an abscess has formed, aspiration of pus and the cultures made from it allow of quick diagnosis. In ten cases the location was in the spine and in some of these, in which the history and the roentgenographic findings were not conclusive, the exact diagnosis was established twenty-four hours after the puncture had been made, as cultures showed abundant colonies of *Staphylococcus aureus* (Case 14, Figs. 13-A and 13-B).

When the lesions are chronic and of the sclerotic type, some difficulty is often encountered in making the puncture, because of bone resistance. In two patients the lesion was of the brucellar type.

Unspecified Chronic Inflammatory Diseases: Seventy-six Cases

In seventy-four cases histopathological examination showed non-specific chronic inflammatory diseases: rheumatoid arthritis, ankylosing spondylitis, synovitis, osteoarthritis, and similar conditions.

Hypertrophic Arthritis (Osteo-Arthritis) and Aseptic Necrosis: Sixteen Cases

In fifteen cases diagnosis was positive and in one, negative.

The aspirated material shows the degenerative lesions characteristic of these diseases and demonstrates the absence of any inflammatory or tumor elements.

Miscellaneous: Twenty-two Cases

These cases consisted for the most part of fracture callus, hematoma, renal osteodystrophy, lipophagic granuloma, and others.

ASPIRATION BIOPSY OF THE SPINE *

The author, in collaboration with Valls and Schajowicz [37, 39], has described in detail a technique for aspiration biopsy of the spine.

* When this paper was read, the author illustrated his personal technique by means of a motion picture.

A special set of instruments composed of a needle guide (Fig. 14, *A*), two needles (Fig. 14, *B* and *C*), and a lined metal plate (Fig. 14, *D*) is used for the biopsy. Figure 15 shows the instruments assembled. The correct position of the needle is at an angle of 35 degrees; this corresponds to the angle of the guide (Figs. 16 and 17).

It must be pointed out that, because of anatomical difficulties which it has not been possible to overcome, aspiration biopsy of the vertebral bodies between the first and the tenth thoracic vertebrae cannot be carried out with this technique (Fig. 18).

The experience which has been acquired has resulted in a routine technique which can be recommended for its simplicity.

It is not intended to enter either into the studies which have been published on the subject or into the modifications introduced into this technique by Turkel and Bethell and by Ray, since the method, when carefully followed, has proved efficacious in every respect. The author, therefore, disagrees with Michele and Krueger who favor open biopsy of vertebral bodies.

The method has given excellent results and is to be considered as a modest contribution toward diagnosing numerous cases in which diagnosis otherwise would have remained doubtful.

Of 204 cases studied and reported, the diagnosis was positive in 171 (83.82 per cent.). In five cases the diagnosis was doubtful (2.45 per cent.) and in twenty-eight, negative (13.72). In five cases the procedure had to be repeated. In 204 aspiration biopsies of the spine, only one complication has been observed; this was a deep hematoma in a patient suffering from generalized plasmacytoma with marked vertebral osteoporosis.

SUMMARY

Aspiration biopsy is a method by which a high percentage of accurate diagnoses may be obtained, provided that the correct technique is followed and the material is examined by specialized pathologists.

Of 1,061 aspirations, results were positive in 84.35 per cent.

The method, which is simple, carries no risk to the patient and does not exclude other methods of diagnosis.

It is particularly useful in deep locations such as the vertebral bodies or the pelvis.

Aspiration biopsy of vertebral bodies may be considered as a definite advance which, because of its simplicity and safety, should become an accepted method of diagnosis.

NOTE: The conclusions we have reached and the high percentage of positive results could not have been achieved without the cooperation of Dr. Fritz Schajowicz, one of the most skilfull bone pathologists of the present day, who has placed at our service his outstanding knowledge. His great experience has been an aid in our diagnostic procedures and a safeguard in their use. The author also wishes to express his gratitude to Prof. José Valls for permission to use the cases from Dr. Valls' orthopaedic clinic.

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ASPIRATION BIOPSY IN BONE LESIONS

Cytological and Histological Techniques

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It is the purpose of this paper to describe in detail the cytological and histological techniques which we have been using in our laboratory for fifteen years. During this period we have had occasion to study more than 1,000 cases of aspiration biopsy of bone lesions and tumors of the soft tissues of the extremities. The clinical studies of these cases have been discussed by Ottolenghi [6].

The correct and effective application of the technical details of the procedure by the pathologist is of fundamental importance if he wishes to obtain a high percentage of positive results.

Like many other pathologists, we were at first sceptical with respect to this procedure, especially because the pioneers of this method, on the Staff of the Memorial Hospital of New York [1, 5, 9, 10], recommended the preferred or exclusive use of the smear, a technique in which considerable experience is required to distinguish the cytological characteristics of the various tumors. For this purpose Stewart advised aspiration of gross tumor specimens which are sent into the laboratory, in order that the diagnostic characteristics shown in the smears from this aspirated material may be compared with the sections on which the histological diagnosis is made.

However, soon after the first attempts, we became enthusiastic about the method, especially when we realized that it was not necessary to carry out difficult cytological interpretations, as it was possible to obtain histological sections after embedding the more important parts of the aspirated fragments in paraffin. The only difference between this and the usual open biopsy is that it requires the pathologist to make his diagnosis from smaller pieces than he would normally.

Frank Ellis in 1947 stated that he used the paraffin-block method almost exclusively.

In our practice we use both methods, giving priority, in the great majority of cases, to the histopathological interpretation of the embedded material, with which we have obtained more satisfactory results. We consider the smear as a very useful complementary medium, of great value for the study of the finer cytological details, especially when we are dealing with diseases of the hematopoietic system. Moreover, the latter often permits a diagnosis to be made within a few minutes. The smear is generally sufficient to diagnose eosinophilic granuloma, myeloma, metastatic carcinoma, and to differentiate between Ewing's sarcoma and osteomyelitis, or between giant-cell tumor and osteolytic osteogenic sarcoma. However, in most cases the smear does not allow us to determine the exact classification of a benign or malignant tumor or, in many instances, to differentiate between metastatic and primary malignant bone tumor, fibroma and fibrosarcoma, chondroma and chondrosarcoma, *et cetera*.

On the other hand, in some neoplastic processes such as fibromatous tumors, in cartilaginous and sclerosing bone tumors, in Paget's disease, and in other lesions in which the connective tissue or osseous stroma predominates, it is generally impossible to obtain more than a few cellular elements, if any, from smear; for this reason we do not use the smear technique in such cases.

Before describing the technique, we wish to emphasize one point which we consider of major importance; this is that the pathologist should have an accurate and complete knowledge of the clinical data and of the exact source of the aspirated material. On this

point we are in complete agreement with Martin and Ellis, who have had extensive experience in aspiration biopsy: "Knowing the source, knowing what tumors are apt to occur in the region, and being fully cognizant of the histological criteria for diagnosis of such tumors on ordinary sections", the pathologist is in the most favorable situation to make a correct diagnosis in the great majority of cases. This has been emphasized by Ottolenghi [6].

TECHNIQUE

The aspirated material is expelled into a sterile test tube, which contains a few centimeters of saline solution. Sometimes it is necessary to push out a plug of tissue from the needle with the obturator. When an inflammatory process is suspected, part of the

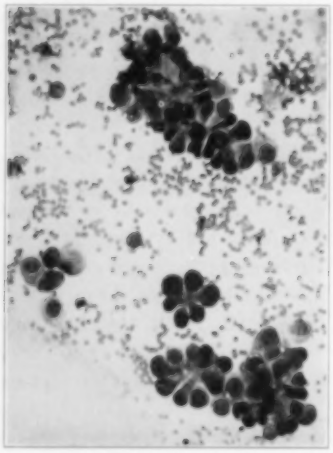

FIG. 1-A

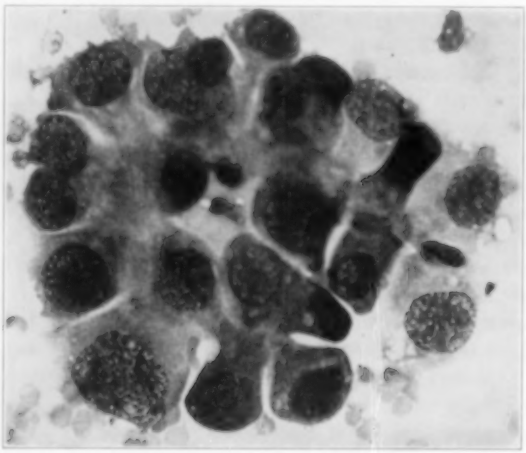

FIG. 1-B

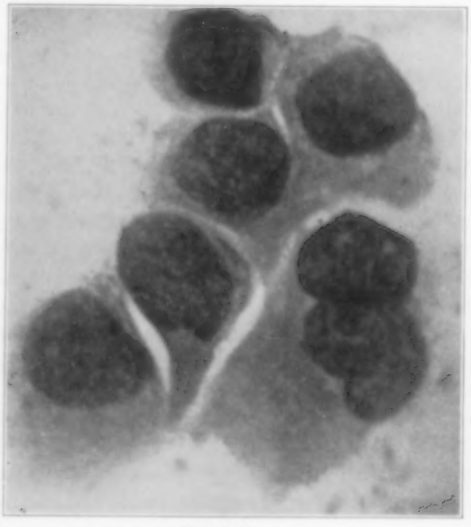

FIG. 1-C

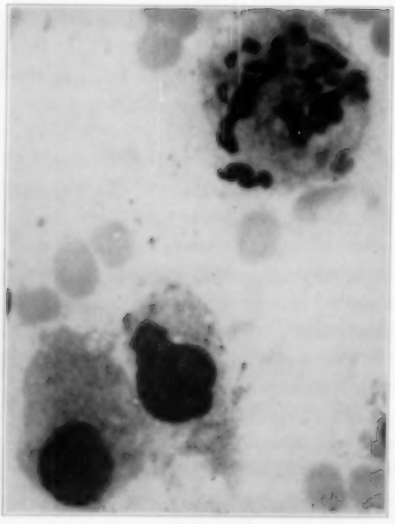

FIG. 1-D

Smears from aspirated material from two cases of metastatic carcinoma, showing characteristic cells. (Stained with May-Grünwald and Giemsa stains.)

Fig. 1-A (low power), Fig. 1-B (high power), and Fig. 1-C (oil immersion) show clumps of tumor cells.

Fig. 1-D (oil immersion) shows a cell with atypical mitosis.

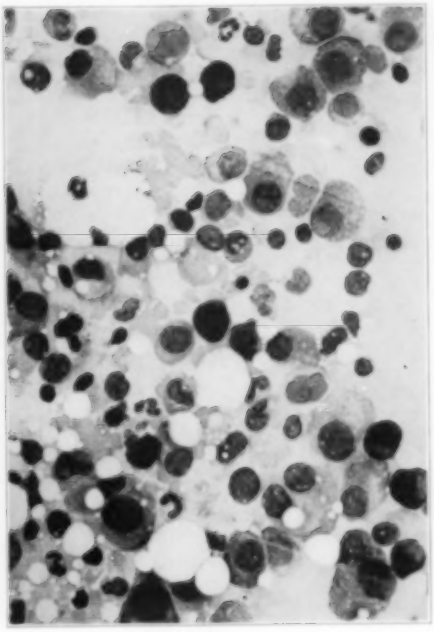

FIG. 2-A
Low power

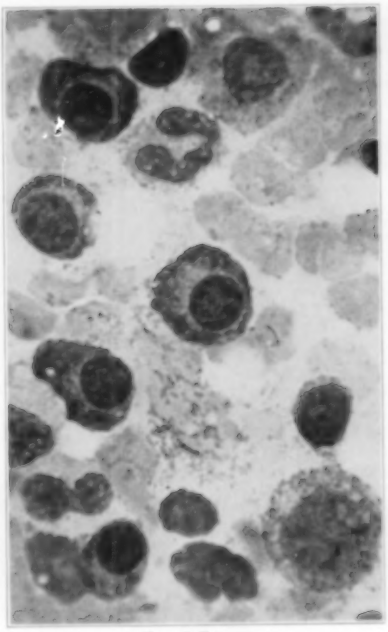

FIG. 2-B
High power

Smears from aspirations of two cases of multiple myeloma, showing numerous plasma cells in different stages of development. (May-Grünwald and Giemsa stains used.)

material is introduced into a second sterile test tube in order to perform the usual necessary bacteriological investigations by means of smears and cultures or, if tuberculosis is suspected, by guinea-pig inoculation.

The material should be sent to the pathologist immediately or at most only a few hours later (having been stored meanwhile in the refrigerator). The pathologist himself must execute the next steps.

The contents of the test tube are placed in a Petri dish and the material is carefully examined. The tissue particles must be separated and removed with a scalpel and a needle from the blood clots with which they are usually mixed; even the smallest fragments should be studied.

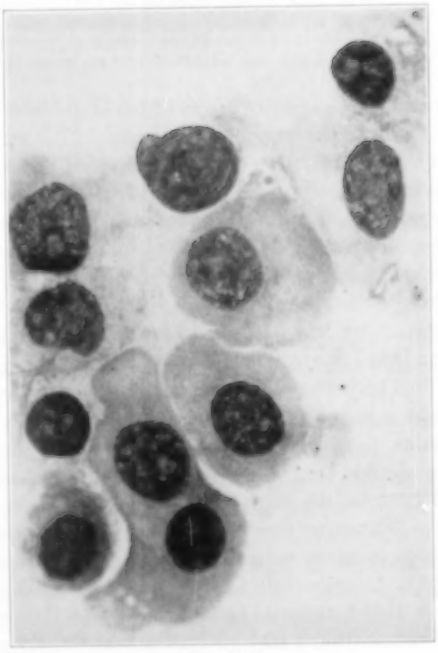

FIG. 2-C
Oil immersion

With some experience it is quite easy to differentiate particles of fibro-adipose tissue from tumor fragments. Occasionally no fragments are visible in the blood clot and in that case the entire specimen must be embedded; however, in such cases it is better to repeat the aspiration. Very rarely is it necessary to centrifuge the aspirated material, and we have never used anticoagulants to

FIG. 3-A

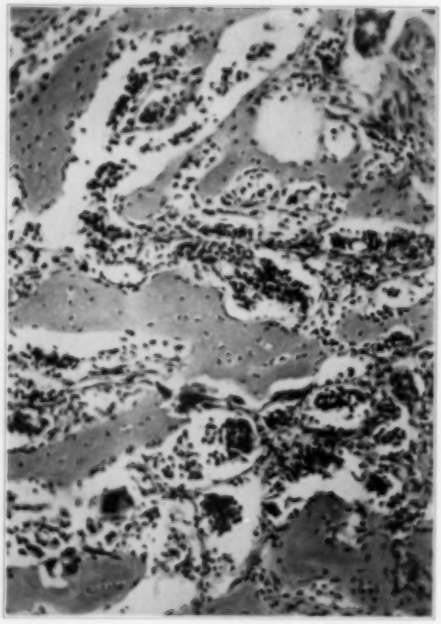

FIG. 3-B

Paraffin sections from a case of metastatic carcinoma of the osteoblastic type.

Fig. 3-A: General view, showing the size of the two cylindrical fragments obtained.

Fig. 3-B: At higher magnification, the number of epithelial-cell groups invading the marrow spaces, surrounded by new-formed bone trabeculae, may be observed. (Fixation in 10 per cent. formalin, decalcification in 5 per cent. nitric acid for six hours; staining with Hansen's hematoxylin and eosin stains.)

avoid the clotting of blood which is so often aspirated with the fragments of tumor tissue.

From the smaller particles and from some of the larger ones, when enough are available, at least three smears are made. The tissue fragment is placed on a slide; a second slide is placed over it, and with slight pressure the tissue is crushed thin and is drawn lengthwise. The tissue may also be smeared by means of the end of a scalpel or a platinum loop. The smears are air-dried for a few minutes; they are not heated over the gas flame.

The first smear is stained with methylene blue (1 per cent. aqueous solution) from three to five minutes; this permits a quick diagnostic orientation. The second smear is stained by May-Grünwald and Giemsa's stains (called also Pappenheim's panoptic method) [4]. The third smear is stained with hematoxylin and eosin.

The best results and the most accurate cytological details are obtained by Pappenheim's panoptic stain (May-Grünwald and Giemsa), which we prefer to the other two stains, particularly when we have only a limited amount of material at our disposal. We do not feel that Papanicolaou's staining has any advantage over the method described, at least for the study of bone lesions.

Whenever possible we leave one or more smears in reserve, in order to carry out supplementary special stains: McManus' method for carbohydrates, Sudan III stain for lipids, Gram's stain for bacteria, and similar procedures.

If the material cannot be sent to the pathologist immediately, as for instance when it comes from a distant medical center, the surgeon may fix it in a 10 per cent. formalin solution; in that case, however, no smears can be made, as fixed material does not give satisfactory results.

The larger and more important fragments are put into a small bottle containing a 10 per cent. formalin solution. The bony fragments are separated and placed in a second bottle with the same fixative for decalcification.

FIG. 4-A
Low power

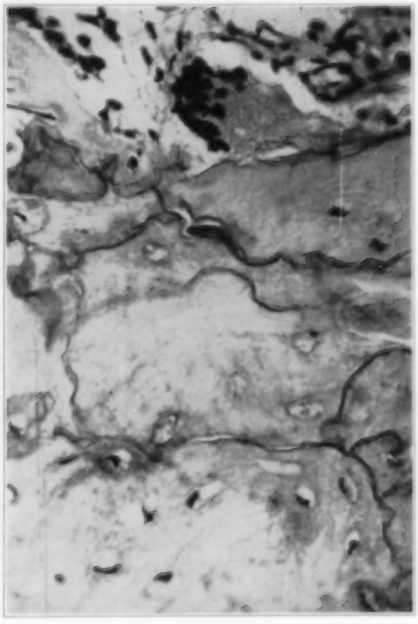

FIG. 4-B
High power

Paraffin sections from a case of Paget's disease, showing the typical mosaic pattern, strands of osteoblasts alternating with osteoclasts and the vascular and loosely textured fibrous tissue in the marrow spaces. (Fixation in 10 per cent. formalin, decalcification in 5 per cent. nitric acid for twelve hours; staining with Hansen's hematoxylin and eosin stains.)

All fragments are treated in the same way and with the same care as any small biopsy specimen. For this reason the usual time for embedding in paraffin can be shortened to the following times:

1. 10 per cent. formalin	1 to 3 hours.
2. 95 per cent. alcohol	Two changes of one-half hour each.
3. Absolute alcohol	Two changes of one-half hour each.
4. Benzol	Two changes of one-half hour each.
5. Paraffin (52 to 56 degrees centigrade)	Two changes of one-half hour each.

Fresh paraffin should be used for embedding and all fragments should be carefully massed together on the same plane. At least ten sections should be cut from different levels; these are stained in the usual way with hematoxylin and eosin.

The fragments containing bone tissue are decalcified, after fixation in 10 per cent. formalin for one to six hours, in 5 per cent. nitric acid (in distilled water) from two to twenty-four hours, the time depending on their hardness. After that they are placed for one to three hours in a solution of 4 per cent. sodium sulphate and are then washed in running water for one to two hours. The succeeding steps are the same as in the embedding of soft-tissue particles already described. The only difference consists in the staining, which in this case is carried out by Hansen's hematoxylin for ten to fifteen minutes, followed by differentiation in a solution of glycerin and acetic acid in equal parts.

Hansen's hematoxylin is prepared as follows:

Solution A	Hematoxylin, 1 gram. Absolute alcohol, 10 cubic centimeters.
Solution B	Potassium alum, 20 grams. Distilled water, 200 cubic centimeters.
Solution C	Saturated solution of potassium permanganate.

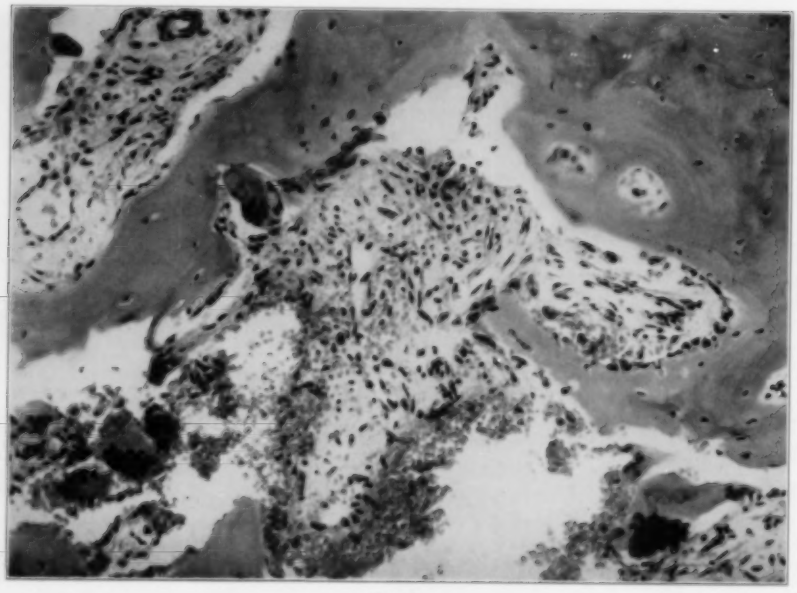

FIG. 5

Paraffin section from another case, showing the typical findings of Paget's disease. (Fixation in 80 per cent. alcohol, decalcification by the method of Greep, Fischer, and Morse for forty-eight hours; staining with Hansen's hematoxylin and eosin stains.)
This technique was used in order to study alkaline phosphatase activity and carbohydrates (glycogen).

The following day solutions A and B are mixed and three centimeters of solution C are added. The resulting solution is heated to the boiling point while the flask is kept in motion; it is cooled rapidly and is then filtered.

HISTOCHEMICAL TECHNIQUES

During the last two years we have been systematically studying dystrophic and neoplastic processes of bone and cartilage, using histochemical techniques the simplicity and exactness of which permit routine application. The first results have been published[7].

This technique has also been used with material obtained by aspiration biopsy when it was possible to aspirate numerous fragments of tissue, particularly in osteolytic tumors. It has been very useful in some neoplastic and other lesions situated in regions, such as the pelvic bones or vertebral bodies, which are difficult or impossible to reach by open biopsy.

In such cases part of the material is fixed in 80 per cent. alcohol at 5 degrees centigrade for twelve to twenty-four hours; thereafter, the technique is the same as that for the embedding of ordinary aspiration-biopsy material. It is, however, more rapid and the vacuum oven can be utilized, especially when studies of enzymes, such as alkaline phosphatase, are required.

Besides the alkaline phosphatase, the carbohydrates—polysaccharides (glycogen) and mucoproteins—can be studied by means of the McManus technique, while metachromatic substances can be investigated by the use of toluidine blue or some other metachromatic stain.

When the aspirated tissue shows bony resistance, it can be decalcified, after fixation in an 80 per cent. solution of alcohol, according to the method of Greep and his associates (equal parts of a 2 per cent. formic acid solution and a 20 per cent. sodium citrate solution) for twenty-four hours or somewhat longer. This, as we have shown in a recent comparative

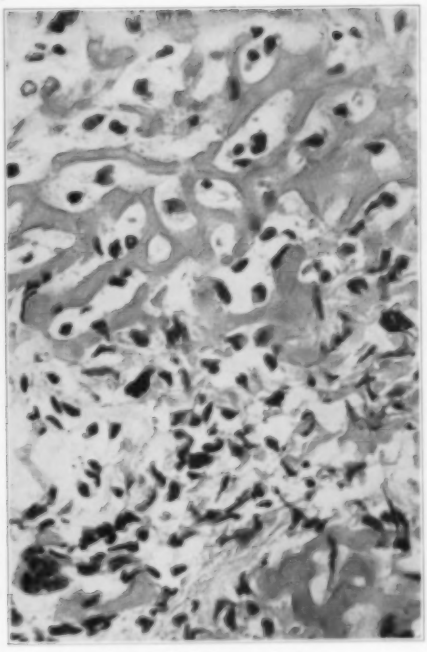

FIG. 6-A

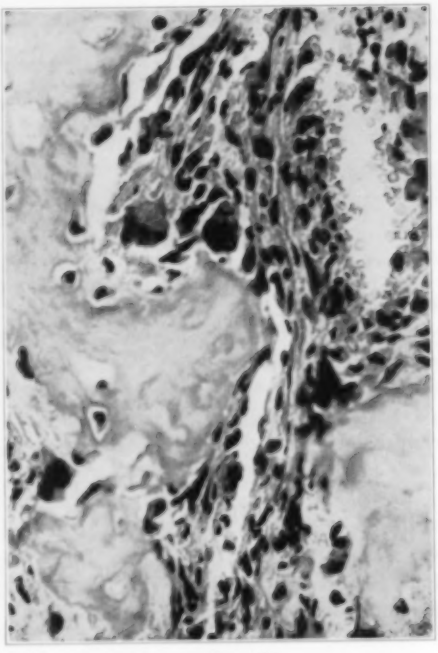

FIG. 6-B

Figs. 6-A and 6-B: Paraffin sections from two different cases of osteogenic sarcoma. (Fixation in 80 per cent. alcohol, decalcification by the method of Greep, Fischer, and Morse for twenty-four hours; staining with Hansen's hematoxylin and eosin stain.)

In these cases alkaline phosphatase activity and glycogen were investigated with the material obtained at aspiration biopsy.

study of the effect of different acids (decalcifying solutions) on the histochemical behavior of bone and cartilage [8], produces fewer alterations and allows the investigation of alkaline phosphatase, glycogen, and metachromatic substances in the decalcified material.

NOTE: The encouraging results obtained in our laboratory with this method are due in great part to the efficient technical work of the surgical staff. They have acquired great experience with aspiration biopsy and almost invariably aspirate abundant material. Appreciation is also expressed to our laboratory technicians whose careful cooperation has been of the greatest importance.

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NON-OSTEOGENIC FIBROMA OF BONE

A Review of the Literature with the Addition of Six Cases

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The term "non-osteogenic fibroma of bone" was introduced into the literature in 1942, when Jaffe and Lichtenstein used it to describe a benign marrow-connective-tissue tumor, specifically not containing any osseous elements. They presented this lesion as a clear-cut entity on the basis of pathological, clinical, and roentgenographic manifestations. They studied ten cases. The lesion had previously been interpreted as one of the following: "giant-cell variant of bone cyst or osteitis fibrosa"; "healing variant of giant-cell tumor"; "xanthic variant of giant-cell tumor"; "solitary xanthoma or xanthogranuloma of bone"; and "fibrous osteomyelitis".

During the past three years, in the Henry Ford Hospital, six cases have been diagnosed which fit this classification. It is our purpose to present these cases as they have been studied. The roentgenographic and pathological findings will be presented in detail to support our contention that these cases represent "non-osteogenic fibroma of bone" as first described by Jaffe and Lichtenstein.

CASE HISTORIES

Case 1. H. G., a fourteen-year-old boy, was first seen at Henry Ford Hospital in October 1952, complaining of pain and swelling in the lower third of the right leg of two weeks' duration. There was no history of trauma. The leg was red and there was superficial venous dilatation. The area was mildly tender to pressure. Initial roentgenograms showed the presence of a cystic type of lesion in the distal end of the di-

Fig. 1-A

Fig. 1-B

Fig. 1-A: Case 1. Preoperative roentgenograms showed a cystic, eccentric, loculated lesion with a well defined medullary border. A periosteal reaction associated with a fracture is evident.

Fig. 1-B: Roentgenograms made seven months after operation.

aphysis of the tibia and a fracture line traversing the posterior cortex in the region of the lesion. The lesion was eccentric, involving principally the posterior and lateral cortex, and extended into the medullary cavity (Fig. 1-A). Skeletal survey and laboratory studies gave normal findings.

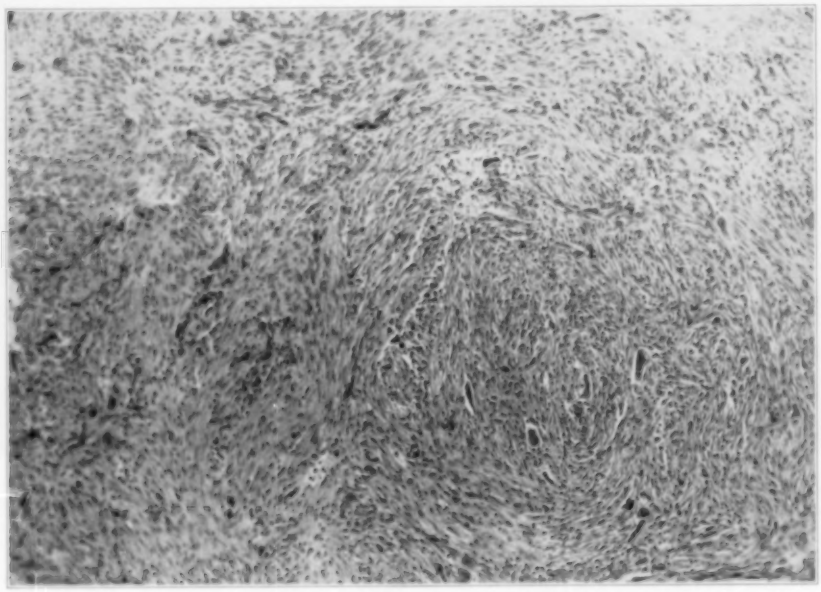

FIG. 1-C

Photomicrograph (× 100). Note the whorled arrangement of fibrous tissue, the presence of giant cells, and absence of bone formation.

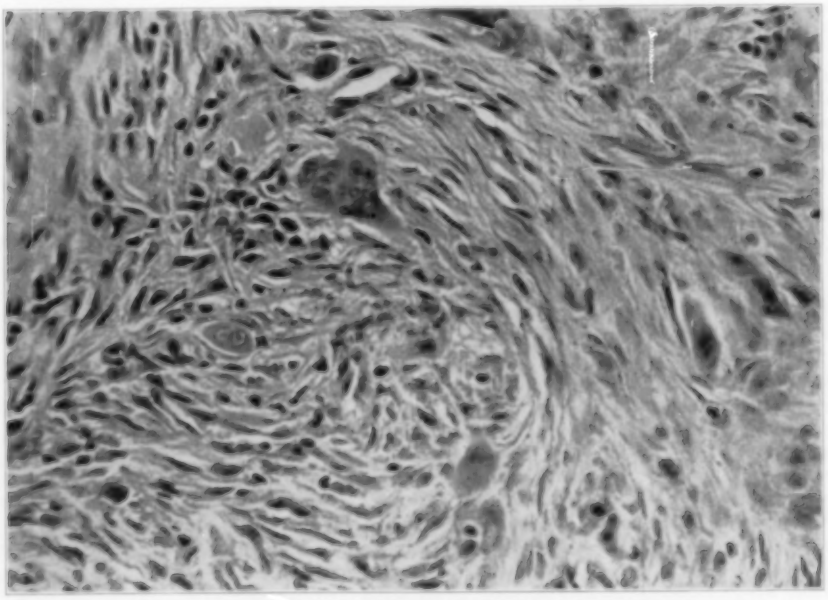

FIG. 1-D

Photomicrograph (× 430). Note the foreign-body type of giant cell in the dense fibrous tissue.

FIG. 2-A

FIG. 2-B

Fig. 2-A: Case 2. Preoperative roentgenograms showed an oval-shaped cystic, eccentric lesion with a thin, well defined medullary border.

Fig. 2-B: Roentgenograms made eleven months after operation.

Operation was performed and grayish-brown soft material, resembling granulation tissue, was removed from the cystic area. The defect was filled with small cancellous-bone chips. No surface abnormality of the tibia was noted in this area. Photomicrographs demonstrated dense interweaving bundles of spindle-shaped cells surrounded by calcified spicules of bone. Focal deposition of hemosiderin pigment accompanied by phagocytosis was a frequent observation. Tumor giant cells were common, as were focal areas of collagenization (Figs. 1-C and 1-D).

Seven months after surgery the patient was still asymptomatic (Fig. 1-B).

CASE 2. R. H., a nine-year-old boy, was first seen at Henry Ford Hospital in May 1951. The boy complained of pain in his left knee which had been present for five months. There was no history of trauma. Before the development of symptoms, the patient's knee had locked and he had been treated with a plaster cylinder over the knee for four or five weeks. When the patient was examined at Henry Ford Hospital, no abnormal physical findings were noted. There was no limitation of motion or tenderness on pressure in the knee region. Roentgenograms revealed an area of radiolucency involving the medial aspect of the tibia about 2.5 centimeters distal to the proximal epiphyseal line (Fig. 2-A).

When this area was examined at surgery, the cavity was filled with reddish-brown, firm tissue. Bone chips were packed in the space. Photomicrographs demonstrated homogeneous sheets of spindle-shaped cells arranged in interlacing whorls and fasciculi. There were large numbers of multinucleated giant cells scattered rather uniformly throughout the tumor (Figs. 2-C and 2-D). The patient had an excellent postoperative course and there has been no recurrence of symptoms to date (Fig. 2-B).

CASE 3. D. R., a fourteen-year-old boy, was first seen at Henry Ford Hospital in December 1951. The day before admission he had slipped on the ice and had turned his right ankle. He complained of pain in the right leg. At examination the leg was swollen, and there was tenderness on pressure over the affected area. Roentgenograms demonstrated an area of radiolucency along the lateral aspect of the lower third of the tibia on the right. There was a spiral fracture through the cystlike structure, extending into the shaft of the tibia above the space (Fig. 3-A). The preoperative diagnosis was pathological fracture. At surgery the cystic area was curetted and the cavity was packed with autogenous cancellous bone.

Microsection of the pale brownish material demonstrated fibrous-like tissue with a tendency to form a whorl pattern. New-bone formation was noted, as was bone resorption in association with the fracture. Infarction was a prominent feature in one part of the lesion (Figs. 3-C and 3-D).

After curettage, the cavity was packed with cancellous bone chips. The postoperative course was quite satisfactory from a clinical standpoint, but progress x-rays showed the persistence of radiolucent areas.

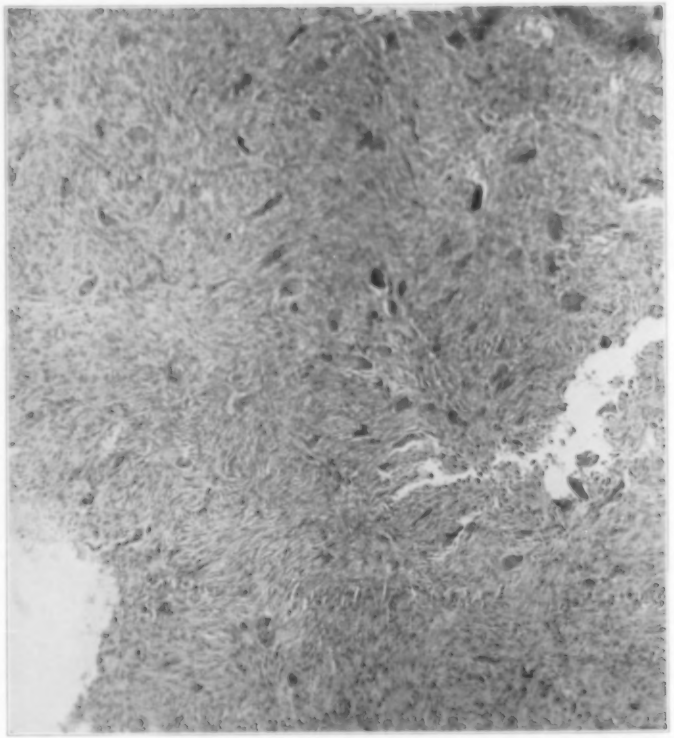

FIG. 2-C

Photomicrograph (× 100), showing the interlacing fasciculi of fibrous tissue and giant cells.

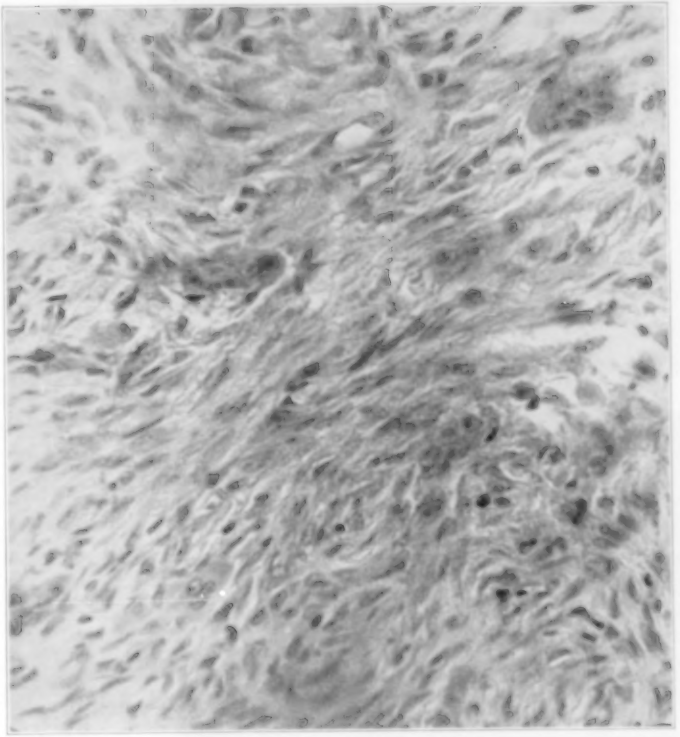

FIG. 2-D

Photomicrograph (× 430), showing the presence of vesicular nuclei in the fibrous tissue.

FIG. 3-A

FIG. 3-B

Fig. 3-A: Case 3. Preoperative roentgenograms showed a fracture through the oval, eccentric, cystic lesion with well-defined medullary border. The cortex is thin.

Fig. 3-B: Roentgenograms made one year after surgery showed persistence of cystic areas and bony spur.

CASE 4. S. H., a fourteen-year-old girl, was admitted to Henry Ford Hospital in September 1951, with a history of moderate pain behind the knee for approximately three months. At the time of examination a slight flexion attitude had developed. She walked with a limp, preferring not to bear weight on her leg. There was muscle spasm. However, full flexion and extension could be demonstrated. Over the posterolateral aspect of the distal portion of the thigh there was tenderness on pressure. There was 1.3 centimeters of quadriceps atrophy on the right. Initial roentgenograms demonstrated an elongated cystic type of lesion in the lower end of the diaphysis of the right femur. The lesion was eccentric and involved principally the posterior aspect of bone (Fig. 4-A). Laboratory findings were normal. When the patient's lesion was examined at surgery, a soft, yellow, lipoid type of material was found within the cavity.

Microsections of the curetted material demonstrated sharply defined nests and solid sheets of spindle-shaped cells arranged in interlacing fasciculi. Foam cells were a prominent feature throughout this rather uniform pattern (Figs. 4-C and 4-D). The patient had an asymptomatic postoperative course, except for scar tenderness. However, x-rays again showed the persistence of radiolucent areas fifteen months after operation.

CASE 5. R. E. S., a ten-year-old boy, was first seen at Henry Ford Hospital in April 1951. He complained of pain in the left leg, which had been present for three days. This was the result of a blow to the left leg by a playmate. At the time of examination the patient was not putting his full weight on his left lower extremity. Initial roentgenograms demonstrated an oval-shaped cystic lesion at the upper end of the diaphysis of the left fibula (Fig. 5-A). Laboratory findings revealed serum calcium of 14.6 milligrams per 100 cubic centimeters and alkaline phosphatase of 11.6 Bodansky units. At surgery the cystic area was found to contain granulation-like tissue, which was curetted. Microsection of the pale yellow material demonstrated fibrous connective tissue arranged in interlacing bundles and numerous multinucleated giant cells (Figs. 5-C and 5-D). The patient has been asymptomatic for the past three years. Recurrence of the lesion was noted twenty-five months after surgery (Fig. 5-B), but no progression of the lesion has been demonstrated over a nine-month period.

CASE 6. C. J. W., a six-year-old boy, was first seen at Henry Ford Hospital in October 1953, with a healing fracture of the left tibia of twelve weeks' duration. The patient had been referred to the Hospital by his local physician, who had recognized that the fracture crossed a cystic lesion in the lower tibia. The patient was in no acute distress and had no complaints referable to his left leg. Roentgenograms demonstrated a cystic lesion in the lower end of the diaphysis of the left tibia and an almost completely healed fracture line was noted across the lesion (Fig. 6-A). Laboratory studies were within normal limits. At operation, the cystic lesion was found to contain yellow-brown, granular, friable tissue; this was curetted and the cavity was packed with cancellous-bone chips. Micro-examination of the tissue demonstrated fibrous connective-tissue

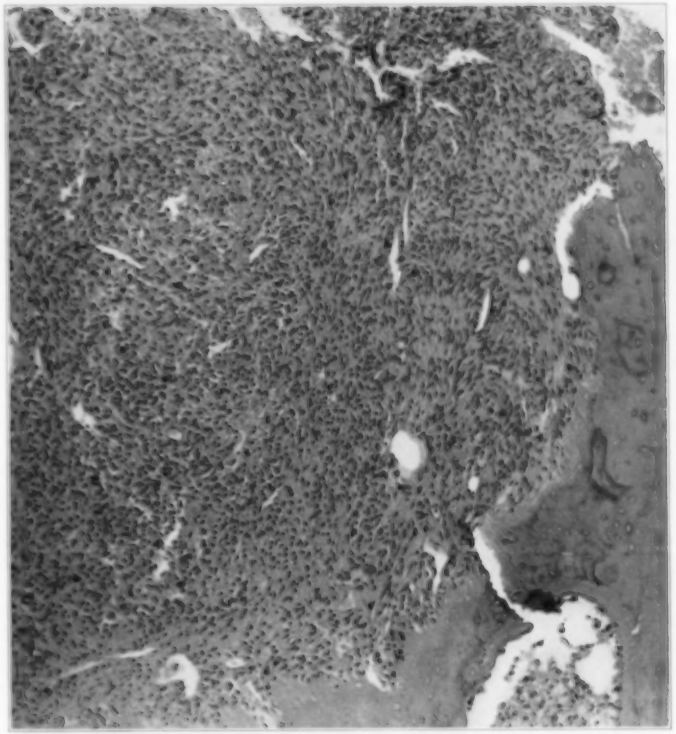

FIG. 3-C

Photomicrograph (× 100). Note the cellular type of fibrous tissue showing tendency to interlace and an eroded bone fragment.

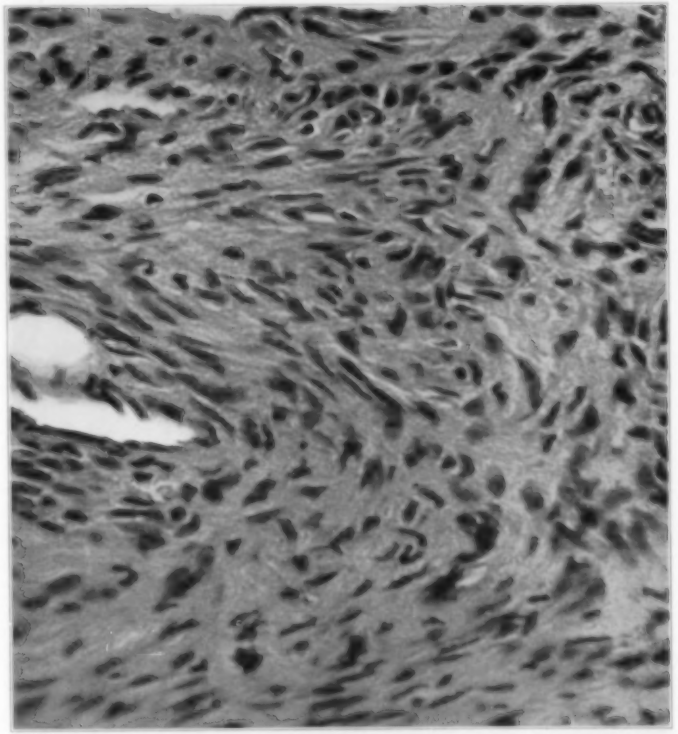

FIG. 3-D

Photomicrograph (× 430). Cellular fibrous tissue showing tendency to interlace. No giant cells are present in this field.

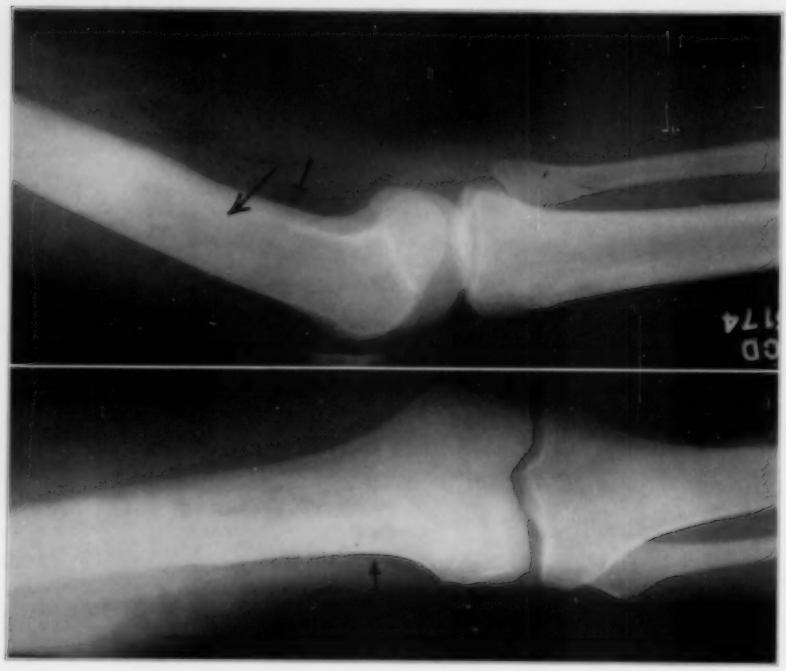

FIG. 4-B

Roentgenograms made sixteen months after surgery showed persistence of the lower end of the lesion.

FIG. 4-A

Case 4. The preoperative roentgenograms showed an elongated, oval-shaped loculated lesion, with a well defined medullary border.

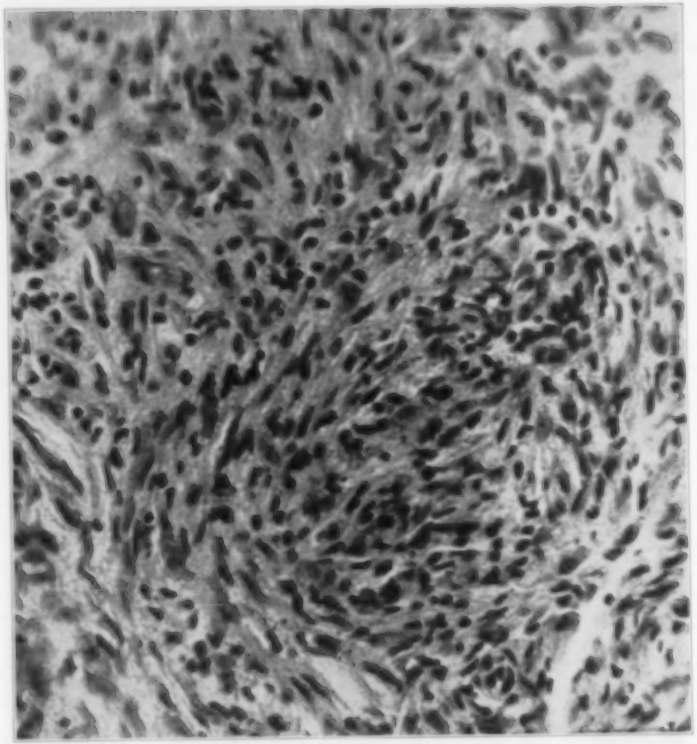

FIG. 4-C

Photomicrograph (× 430) showing dense, cellular fibrous tissue with interlacing pattern.

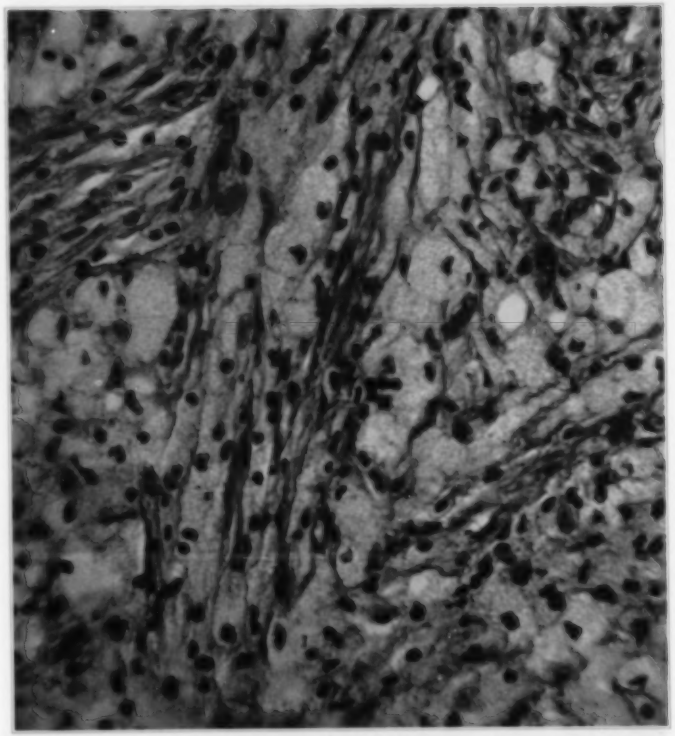

FIG. 4-D

Photomicrograph (× 430) showing foam cells which were a prominent feature in this case. Giant cells were absent in the sections studied.

Fig. 5-B

Fig. 5-A

Fig. 5-A: Case 5. Preoperative roentgenograms showed the thin cortex and an eccentric, loculated cystic lesion. In one area, almost the whole width of the medullary cavity was occupied by the lesion.

Fig. 5-B: Roentgenograms made twenty-five months after surgery showed recurrence of the lesion.

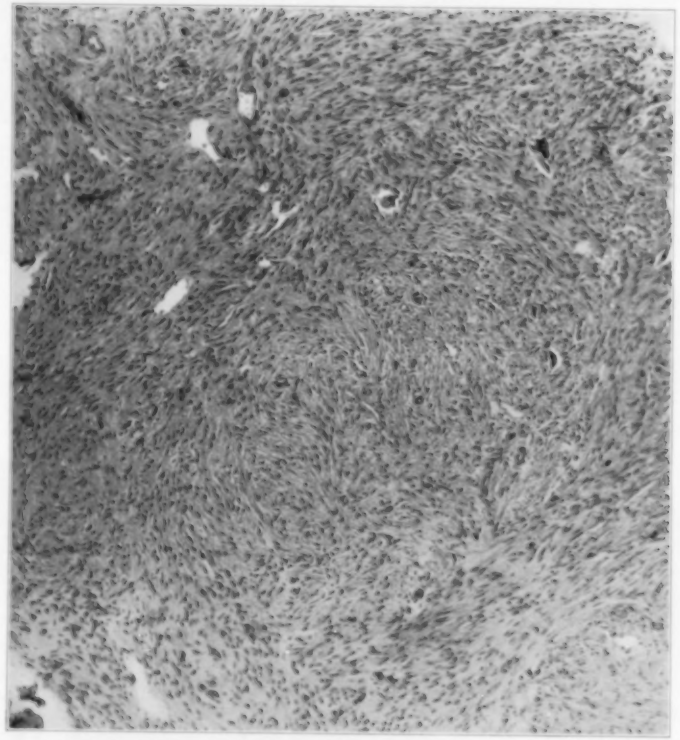

FIG. 5-C

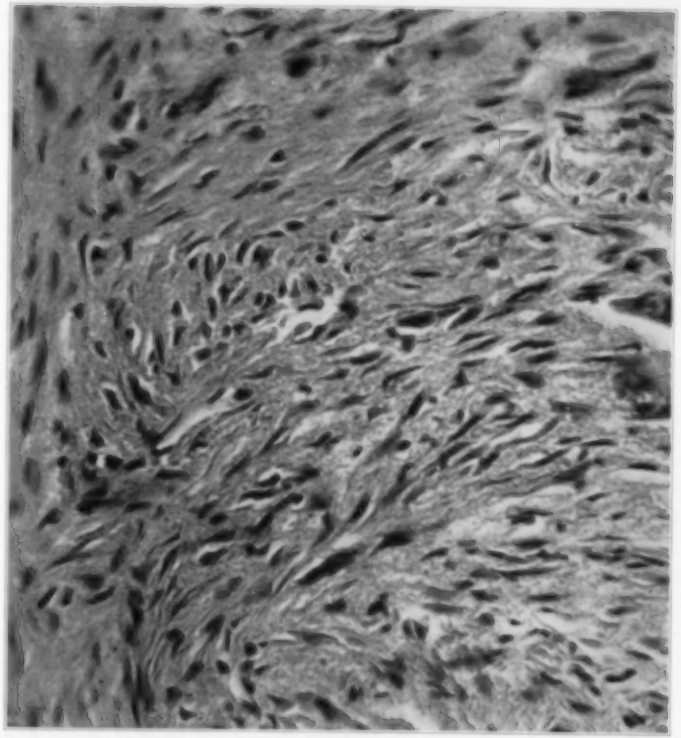

FIG. 5-D

Fig. 5-C (× 100) and Fig. 5-D (× 430): Note the fibrous tissue showing whorl formation. Giant-cell formation was not significant in this field, although other sections demonstrated numerous multinucleated giant cells.

cells in a whorled pattern. There were many small giant cells. In some fields the giant cells were more numerous (Figs. 6-B and 6-C). When he was seen eleven months after operation, the patient was asymptomatic. Roentgenograms made at that time showed persistence of two cystic areas, the appearance of which had not changed from that in the x-rays made immediately after operation.

DISCUSSION

The six cases which we have presented represent benign tumors which have arisen from the connective tissue of bone marrow and which have not shown any evidence of osseous metaplasia during the development of the proliferating connective tissue. Five of the patients were males and one was a female. The ages of the patients ranged between six and fourteen years. The lesion affected a long tubular bone and the lower extremity in all instances. The tibia was involved in four of the cases, the femur in one, and the fibula in one. There was local trauma associated with the discovery of the lesion in half of the cases (Cases 3, 5, and 6). In Cases 3 and 6 there was a fracture of the bone involving the tumor area. In the other three cases there was no history of trauma, but there were localizing symptoms in two (Cases 1 and 4) and a fracture in the involved area in one of these (Case 1). The other patient (Case 2) had mild regional symptoms and had been treated for possible internal derangement of the knee joint for a period of five weeks after his original complaint.

The roentgenographic findings were fairly similar throughout. The lesions were all located in the ends of the shafts of the long tubular bones close to, but not reaching, the epiphyseal plate. They were all eccentric and somewhat oval in outline, with the greatest diameter in line with the long axis of the bone. Only the fibular tumor tended to extend completely across the bone. There was variation in the extent of loculation, but loculation was a constant finding. A well defined medullary border was found in most instances. The cortex was thinned in the involved area in four of the cases (Cases 1, 2, 5, and 6). The size of the lesions varied slightly, but they were all in the region of the 3.8-centimeter length which Jaffe and Lichtenstein[4] described as being usual. Certainly none of them approached the fifteen-centimeter length described by de Moraes and Fialho.

FIG. 6-A

Case 6. Preoperative roentgenograms showed a cystic, eccentric, loculated lesion with evidence of recent fracture.

In only one case, our latest (Case 6), was a definite impression of non-osteogenic fibroma formed after physical and roentgenographic examination. The authors of the original article on non-osteogenic fibroma[4] contended that a correct diagnosis can often be made from the roentgenogram alone. It is our impression that this is true and it will be seen, from study of these cases, that there are some fairly constant roentgenographic findings. However, it is not advisable to rely on the roentgenographic diagnosis alone.

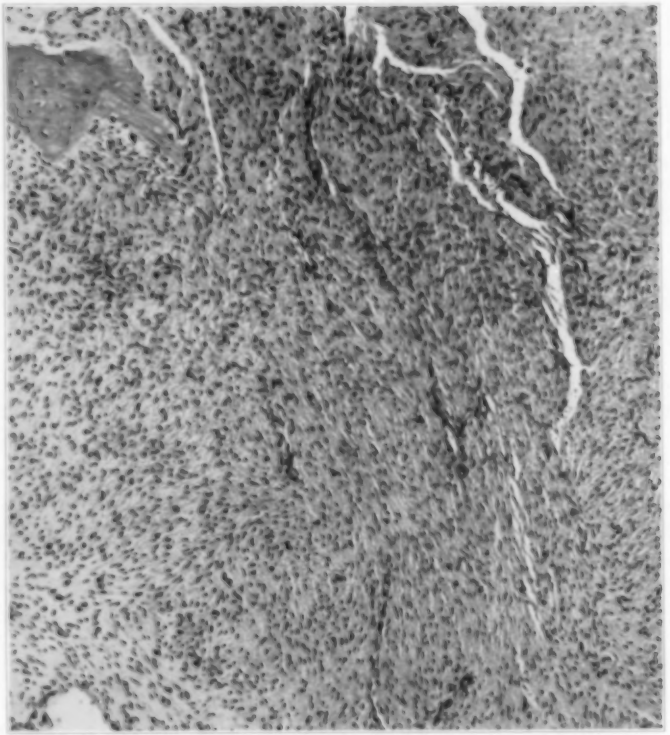

FIG. 6-B

Photomicrograph (× 100), showing interlacing of fibrous tissue. Giant cells were not numerous in the sections studied.

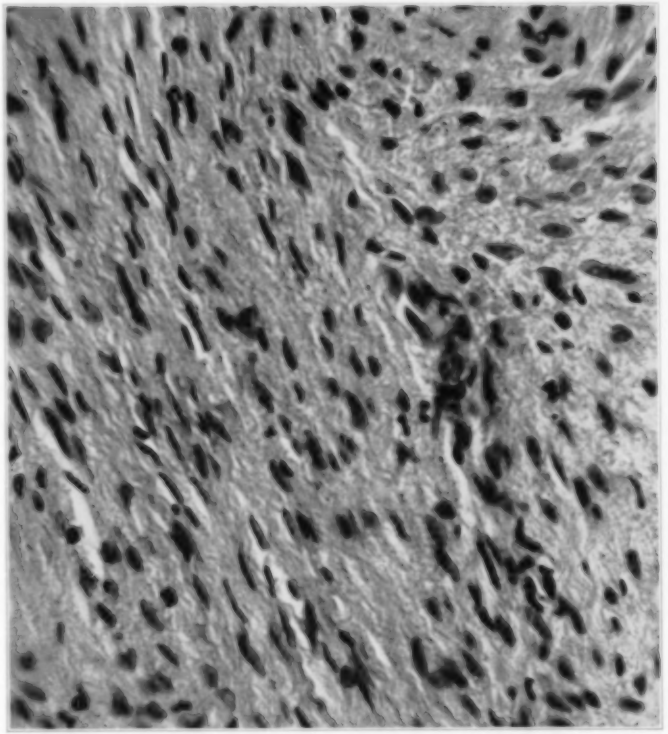

FIG. 6-C

Photomicrograph (× 430). In this section there was less tendency toward whorling of fibrous tissue. Giant cells were not numerous in this field.

TABLE I

SUMMARY OF CASES

Case No. Initials	Age (*Years*)	Location	Predominant Pathological Picture	Roentgenographic Findings	Treatment	Result
Case 1 H. G.	14	Lower end of tibia	Friable pale tan and dark brown material. Loose, interweaving, spindle-shaped, fibrous-tissue cells. Giant cells. No atypical features. No mitotic figures.	Cystic lesion. Eccentric, involving posterior cortex. Locules. Sclerosed medullary border. Fracture. Periosteal reaction.	Curettage. Packing with cancellous bone.	Roentgenographic evidence of healing at about five months. No periosteal reaction. Asymptomatic.
Case 2 R. H.	9	Upper end of tibia	Reddish-brown firm tissue. Homogeneous sheets of spindle-shaped cells. Interlacing whorls and fasciculi. Giant cells.	Cystic lesion. Eccentric. Posterior and medial cortex involved. Sclerosed medullary border. Locules.	Curettage. Packing with cancellous bone.	Two small radiolucent areas persist after one year.
Case 3 D. R.	14	Lower end of tibia	Pale and brownish material. Cellular type of fibrous tissue. Areas of bone formation and bone absorption.	Cystic lesion. Eccentric. Well defined medullary border. Fracture through the area and into the shaft. Locules.	Curettage. Packing with cancellous bone.	Small radiolucent areas persist after one year. Asymptomatic.
Case 4 S. H.	14	Lower end of femur	Yellowish-gray, somewhat chalky-appearing tissue. Spindle-shaped cells arranged in interlacing fasciculi. Foam cells.	Cystic lesion. Eccentric. Well defined medullary border. Locules. Medullary border is thin but dense.	Curettage.	Persistence of lower portion of lesion 1⅗ years after surgery. Asymptomatic.
Case 5 R. E. S.	10	Upper end of fibula	Periosteal reaction. Newly forming bone. Interlacing bundles of fibrous tissue. Large multinucleated cells. Macrophages containing fine granular pigment.	Cystic lesion. Eccentric. Thinned cortex, showing longitudinal fracture on lateral view. Locules. Medullary border not dense.	Curettage.	Recurrence. Clinically good after 2 years and 7 months.
Case 6 C. J. W.	6	Lower end of tibia	Brownish-yellow granular material. Interlacing bundles of spindle-shaped cells. Giant cells.	Cystic lesion. Eccentric. Locules. Thinned cortex. Healing fracture.	Curettage. Packing with cancellous bone.	X-rays show persistence of cystic areas 11 months after operation. Asymptomatic.

The gross and microscopic appearances varied somewhat. Generally, even in the presence of a healing fracture, the periosteum stripped easily from the bone, as it usually does in young patients. In some cases the cortex was quite thin, and in the fibular lesion thinning was very pronounced. Adherence of part of the tumor tissue to the palpably irregular medullary aspect of the cortex was a constant finding. This irregularity was due in part to the presence of bone spicules which surrounded foci of fibrous tissue. The removed tumor tissue varied in color from yellow-gray to dark brown. There was variation within individual lesions.

When our first patient was studied, the opinion of leading pathologists was sought with regard to the interpretation of the microscopic picture. Two agreed that the lesion had the appearance of non-osteogenic fibroma; one pathologist called the lesion a giant-cell variant; another pathologist did not form a definite impression. Our later cases gave rise to less discussion.

Basically the lesions consisted of spindle-shaped connective-tissue cells showing a tendency to interlace or to form whorls. The cellularity of the lesions varied and there was variation in cellularity within individual lesions, as shown by the photomicrographs of Case 6. In most of the lesions giant cells were a prominent feature and in some areas of a particular focus they were more numerous. Usually the giant cells were small and somewhat elongated. In many fields there was hemorrhage, but generally the tumors did not have a profuse blood supply.

Perhaps it should be emphasized that giant cells may be seen in many bone tumors other than giant-cell tumor; and that most, if not all, so-called giant-cell tumors occurring in patients under ten years of age (and probably, according to Jaffe and Lichtenstein, in patients under twenty years of age) are not giant-cell tumors but fibromata or cysts.

Foam cells were demonstrated in only two of our cases. Jaffe and Lichtenstein found them lacking in about half of their cases. De Moraes and Fialho did not find them in their reported case. The inconstant presence of lipid and the interpretation sometimes given to lesions in which lipid material is found have led Jaffe and Lichtenstein [4] to decry the regarding of such lesions as expressions of lipid granulomatosis and to object to calling them solitary xanthoma, xanthofibroma, or xanthogranuloma. Most pathologists agree that the diagnosis of bone tumors from the microscopic picture alone will lead to many errors. Probably as many errors will be made by allowing a particular microscopic feature to determine the name of a lesion, in part or in whole, especially if that feature is variable and can be found in other unrelated lesions. In non-osteogenic fibroma the microscopic pattern is the determining factor and may support or disprove a roentgenographic diagnosis or clinical impression. In the case described by Onarir there was a diagnosis of osteogenic sarcoma of the femur until biopsy and microscopic examination showed the presence of a non-osteogenic fibroma.

It is true that osteogenic sarcoma or slow-growing fibrosarcoma may be considered in the differential diagnosis, but these are easily ruled out when the microscopic features are studied. Simple bone cyst [4], osteitis fibrosa, giant-cell tumor [5, 7], and fibrous dysplasia [6] more frequently enter into the differential diagnosis. The separation of non-osteogenic fibroma from these lesions is discussed at length by Jaffe and Lichtenstein in their paper on non-osteogenic fibroma of bone. These authors do not agree with Geschickter and Copeland regarding the relationship between solitary bone cyst, osteitis fibrosa, and giant-cell tumor. They classify these lesions separately and believe that non-osteogenic fibroma can and should be isolated from each of these. In our study we have not encountered great difficulty in distinguishing the lesion; this is due in part to making full use of the clinical and roentgenographic findings in combination with the gross and microscopic pathological findings. The pathological findings have stimulated a review of the clinical history and roentgenograms, and this has occasionally resulted in a better understanding of the lesion.

All of our cases were treated surgically. The lesion was curetted in all instances and in four cases the cavity produced was packed with cancellous bone. In three of the cases there was evidence of persistence of part of the lesion after surgery. These defects were noted as long as one year after surgery; they showed no increase in size. In another case the lesion recurred. This was the case in which the upper end of the fibula was involved. During the first postoperative year, none of the patients had any symptoms related to the lesion. The patient whose lesion recurred was not having any difficulty when he was examined two years and seven months after surgery. He was then enjoying full outdoor activity. No progression in the size of the lesion was seen over a seven-month period.

Jaffe and Lichtenstein [4] reported no recurrences in their series of surgically treated cases. In three of their cases in which the lesion involved a slender bone, the affected part was resected subperiosteally. This procedure would probably have been more effective than curettage in our patient with the fibular lesion.

We also feel that more complete curettage had been indicated in those cases which showed persistence of part of the lesion after surgery. None of our patients received radiation therapy. In the case described by de Moraes and Fialho the patient had received radiotherapy over a six-month period without any obvious beneficial effect. In their original article, Jaffe and Lichtenstein stated that they did not know whether non-osteogenic fibroma of bone would respond to radiation therapy alone. There is now knowledge of one case [7] which failed to respond. Surgical removal of the lesion is the treatment of choice and offers excellent results, as well as the best opportunity for the proper gross and microscopic study. We feel that, when any evidence of the existence of non-osteogenic fibroma is presented, complete investigation of the lesion should be undertaken and the affected area of bone should be either excised or thoroughly curetted. If the lesion is left untreated, a pathological fracture is liable to occur, and symptoms may persist. Packing the curetted area with cancellous bone hastens healing.

SUMMARY

The clinical history and the roentgenographic and pathological findings in six cases of non-osteogenic fibroma of bone have been included in some detail in the hope that recognition of this lesion as a distinct entity will be made somewhat easier and that this diagnosis perhaps will be more frequently considered when tumors of bone, especially in the cortical metaphyseal region, have to be treated. Complete curettage or subperiosteal resection of the affected area is supported as the method of treatment.

NOTE: Our photomicrographs were made by Mr. Arthur Bowden and our photographs by Mr. John Kroll and Mr. Walter Harlan. We sincerely thank them for their excellent cooperation.

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VASCULAR AND NEURAL COMPLICATIONS IN SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN

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Supracondylar fractures of the humerus in children are of interest not only to the orthopaedic surgeon but also to the general practitioner, to whom most patients who have these injuries find their way primarily. No matter how disturbing the fracture of the bone may be to the child, the family, and the physician, the presence of disturbance of circulation, motion, or sensation of the extremity distal to the injury delegates treatment of the fracture to a place of secondary importance in the more important treatment of the extremity as a whole.

Watson-Jones lists supracondylar fractures of the humerus first in the causes of palsy of the radial nerve, second as a cause of palsy of the median nerve, and fourth as a cause of palsy of the ulnar nerve. He also pointed out that most of the recorded instances of Volkmann's contracture were in the upper extremity and were due to involvement of the brachial artery at the level of a supracondylar fracture of the humerus.

According to Meyerding, the mechanism of supracondylar fracture predisposes to neural and vascular injuries. He stated that the injuring force carries the condyles backward and strips the periosteum away from the posterior surface of the proximal fragment; this space promptly fills with blood. Also, the lower end of the proximal fragment is carried forward and downward, piercing the anterior aspect of the periosteum and forcing its way against the soft tissues. The blood vessels and nerves thus become compressed by fragments of bone and by blood that infiltrates the antecubital fossa. It is evident that the nerves in this region might be contused, compressed, restricted by scar, or lacerated. Likewise, the vessels may be compressed, contused, thrombosed, perforated, or even severed (Fig. 1).

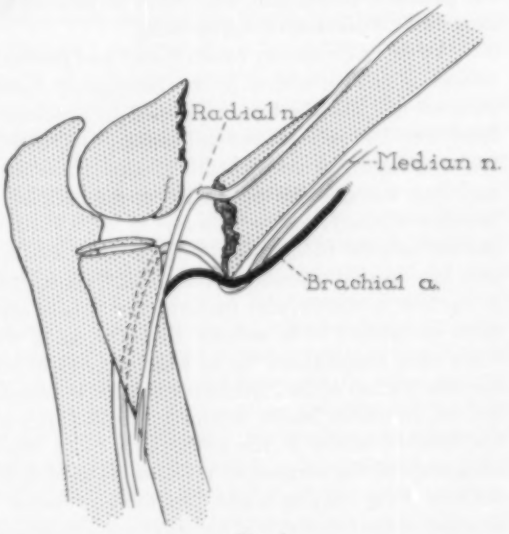

FIG. 1

Mechanism of injury of the brachial artery and the median and radial nerves in supracondylar fracture of the humerus.

It is the purpose of this paper to call attention again to the complications of supracondylar fractures of the humerus, in order to make possible their early recognition, and to provide an outline of the treatment which best prevents irreparable damage from such complications. It is not our purpose to deal with the types of treatment of supracondylar fractures *per se* and their results, as Coventry and Henderson are studying that phase.

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PRESENT STUDY

The records in all cases of *fresh* supracondylar fractures of the humerus encountered in patients fourteen years of age or younger who were seen at the Mayo Clinic from 1943 through 1952, inclusive, were reviewed for evidence of neural and vascular injuries. Only the *extension* type of supracondylar fracture was included in this series, as it was in this type that all of the complications of note occurred. No vascular or neural injuries occurred in the *flexion* type of supracondylar fracture or in medial and lateral condylar fractures in this age group. All of the patients were seen during the acute stage,—that is, immediately after the injury or within the first two weeks.

The incidence of complications in our series was high, since many of these children were referred because of the severity of their injuries and the complications under discussion. Many of the patients who had the vascular and neural complications listed had undergone attempted reduction of the fracture by a local physician, sometimes with and sometimes without success. However, in all cases, the physicians had failed to note improvement in the vascular status of the extremity. These patients then came to the Clinic for emergency care because of this complication rather than because of the fracture. Usually the referring physician telephoned that the child was on his way. We then awaited the patient's arrival and were ready to proceed as necessary in an attempt to prevent an impending Volkmann's contracture.

An accurate history of the injury and previous treatment was obtained, and the child was examined on arrival at the Emergency Room. As already indicated, many of these children had already been subjected to anaesthesia and manipulation of the fracture at least once and perhaps several times. Nevertheless, if reduction had not been successful, we immediately proceeded with manipulation, with the patient under general anaesthesia, and then watched the circulation of the extremity carefully for at least twenty to thirty minutes. Usually, but not always, in those instances in which primary manipulation was carried out, the radial pulse, when absent, returned, and the extremity distal to the fracture lost its cold cyanotic appearance. This is such a common observation after reduction of routine supracondylar fractures that these temporary vascular complications are not often considered to be serious. However, all of the patients who had supracondylar fractures were hospitalized for at least forty-eight to seventy-two hours after manipulation for observation of the circulatory status. If adequate circulation distal to the fracture did not return within twenty to thirty minutes after manipulation and reduction, we explored the brachial artery in the antecubital fossa. We became convinced that it is the moral obligation of the surgeon to proceed, as we did, with exploration of the antecubital fossa without delay, day or night, providing of course that the time interval is such that the changes in the forearm and hand are not irreversible. When there were neurological deficits without evidence of vascular injury, no immediate primary operation was done for the neural involvement.

RESULTS

During the ten-year period included in this study, 108 supracondylar fractures of the acute extension type were seen at the Clinic. In this group, seventy-three fractures occurred on the left and thirty-five on the right, a ratio of approximately two to one. This agrees with the findings of Holmberg, who noted a similar ratio. He pointed out that the reason for the greater frequency of accidents affecting the left side is uncertain but that it is probably due to the fact that in right-handed persons the left arm has weaker muscles and possibly is used in a less skillful way. Another possibility pointed out by Holmberg is that the left arm is used more often than the right in motions of protection and guarding and is, therefore, more prone to injury.

In our study, 73 per cent. of the fractures were in boys and 27 per cent. in girls. This finding also agrees closely with that of Holmberg, who stated that two thirds of the frac-

tures in his study were in boys. He explained this predominance in boys by the fact that they are livelier than girls and their games are rougher.

Among the 108 fractures included in the study, there were twenty-four instances of neural and vascular injuries, an incidence of 22 per cent. As already indicated, this percentage is probably greater than would be expected normally because of the nature of the referred practice at the Clinic. Of these twenty-four patients, eleven had injuries to the brachial artery and seventeen had neural injuries. Both vascular and neural injuries occurred in four patients, thus accounting for a total of twenty-eight injuries in twenty-four patients.

ARTERIAL COMPLICATIONS

As just mentioned, eleven instances of injury to the brachial artery occurred. Early Volkmann's ischaemia was present on admission in one patient, who was first seen thirteen days after the initial injury. The radial pulse was not detectable, the hand was cold, motion was restricted, and some clawing of the fingers was present on admission. Procaine was used to block the stellate ganglion; the ulnar, radial, and brachial arteries were stripped of their sympathetic nerve fibers and the fascial envelopes of the flexor muscles in the forearm were opened. Lengthening of the flexor tendons was carried out later. The adverse conditions noted in this patient on admission were irreversible, illustrating the importance of early and adequate treatment if Volkmann's contracture is to be prevented. Blount stated that irreversible changes are present as early as three or four hours after injury.

Two patients were observed who had no radial pulse on admission, but the color and temperature of the extremity revealed adequate collateral circulation; therefore, conservative treatment was used. This coincides with Blount's idea that absence of the radial pulse in itself is no indication for surgical intervention if the circulation is adequate.

Eight patients, who were seen from one to seventy-two hours after injury, had no radial pulse and, in addition, had embarrassment of the collateral circulation of the extremity. These patients, who had cold and cyanotic extremities, were treated by open operation, since manipulation of the fracture did not improve the vascular status. These operations did not represent open reductions of the fractures but explorations of the antecubital fossa. Two of the eight patients had actual rupture of the brachial artery. One of these patients has been reported on previously by Spear and Janes; in the other patient, the radial pulse could be palpated again in six weeks. In two other patients, the brachial artery was thrombosed, and resection of the involved segment was necessary to relieve the associated arterial spasm. In two patients, the artery was found to be stretched over the proximal fragment of the humerus, and arterial spasm was noted in the distal portion. Although in each instance tension was removed from the brachial artery, and although the artery was bathed in an isotonic solution of sodium chloride and in 1 per cent. solution of procaine, the distal spasm was not relieved until the segment of artery which had been stretched over the fragment of bone had been excised. The artery in one patient was found to be pinched in a longitudinal split in the proximal fragment of the humerus. It was with difficulty that this segment of the artery was released after resection (Fig. 2). In the eighth patient, the artery was impaled within the medullary canal of the proximal fragment of bone by a spicule of loose bone, much as though a thumbtack had been used.

In only two of these eight patients in whom the antecubital fossa was explored surgically was there any question as to irreparable damage to the brachial artery to such an extent that this structure was incapable of transmitting blood. We had everything to gain and nothing to lose by resecting the damaged segment in the other six patients in hope of reducing the concomitant spasm of the collateral vessels in these extremities. As pointed out by Griffiths, the treatment of the artery found to be in spasm at the time of operation presents more of a problem. This problem was present in the two patients in whom the artery was stretched over the proximal fragment of the humerus. After all known conserva-

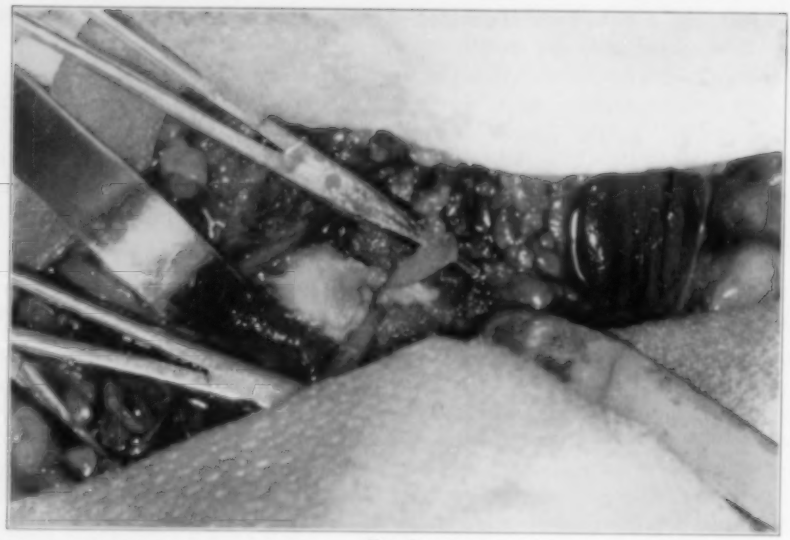

FIG. 2

Brachial artery impinged on the proximal bony fragment in supracondylar fracture of the humerus.

tive measures had failed to release the spasm and in light of our experience in other cases, we decided to resect the artery at the point where the spasm began. In each instance this was at the level of the fracture, thereby signifying possible damage to the arterial intima which was not visible macroscopically. Because of the rich collateral circulation about the elbow, it is our present belief that resection of the brachial artery at this level with concomitant release of spasm in the collateral vessels and distal portion of the artery, as noted by Leriche, offers much less risk to the patient than does prolonged spasm of this vessel and the collateral vessels. This appears to be true especially in children. Applied above the level of the elbow, the idea of such a resection may be untenable.

Thus, the injuries in these eight patients were treated by resection of the damaged segment of artery. This operation was followed by block of the stellate ganglion by means of procaine, in order to facilitate the return of collateral circulation. It is important to note that Volkmann's ischaemia did not appear in any of these patients, and recovery of function was complete in all. Had these patients not been treated as they were, it is our opinion that Volkmann's ischaemic contracture would have developed in some.

NEUROLOGICAL COMPLICATIONS

As already mentioned, injuries to nerves occurred in seventeen of the 108 patients (16 per cent.). Watson-Jones states, "In about 15 per cent. of supracondylar fractures, the median or ulnar nerves are contused. . . ." Hanlon and Estes noted that in ninety-eight fractures of the humerus twelve (12.3 per cent.) were complicated by neural lesions. Two patients had involvement of more than one nerve,—namely, the radial and ulnar nerves in one patient and the radial, ulnar, and median nerves in the other. In the entire group of neural injuries, we found that trauma to the radial nerve was most prevalent, eleven such injuries being reported; seven instances of trauma to the median nerve were included, with only two instances of trauma to the ulnar nerve. The latter two injuries were associated with pronounced contusion and hemorrhage of the entire antecubital region and elbow.

Five of these seventeen patients were treated expectantly; function returned or began to return in two or three weeks. Follow-up examinations showed that full neural function

was restored in all of these five patients. Open reduction was done in three of the remaining patients because of the fracture, but the injured nerve was seen in only one. In these patients, the damage was to the radial nerve and the palsy in each was temporary. The final results were good.

As indicated previously, injuries to nerves in four patients accompanied trauma to the brachial artery, and operations were performed because of the vascular lesion rather than because of the acute palsy of the nerve. As would be expected, the median nerve was involved in all four, but surgical treatment for the injury to the nerve itself was not indicated. These patients experienced temporary paralysis of the long flexors of the thumb and index finger. It could be supposed from this finding that it is the posterior bundle or bundles of the median nerve (which would be nearest to the fractured fragments and most easily injured) which supply the motor fibers to the flexors of the thumb and index finger.

In one patient who had radial palsy, open reduction of the fracture was performed early, and tension on the nerve was thereby released.

Surgical exploration for the neural lesion itself was necessary in only four patients and then only after an observation period of three to four weeks. During this period no improvement occurred in neural function, although the fracture initially had been reduced successfully and in most instances was practically healed. In no patient was a nerve found to be divided. Rather, the nerves were compressed by old hemorrhage, bound down by fibrous tissue, or stretched over a fragment of bone. Neurolysis was performed in two patients who had palsy of the radial nerve, and function returned in both. The same procedure was done in one patient who had palsy of the median nerve, and recovery ensued. In the patient who had involvement of three nerves, neurolysis was done on both the median and radial nerves four weeks after injury; early neuromata were found in each at the level of the fracture. The ulnar nerve was freed during operation but was not transplanted.

Recovery was complete in every patient except in the one in whom palsy of three nerves was present. Ten years later, this patient exhibited some weakness of the intrinsic muscles of the hand. Flexion and extension of the fingers and wrist, as well as sensation, were intact.

We admit that some of these lesions probably would have resolved spontaneously. On the other hand, most of these patients were studied both clinically and by electromyography prior to surgical intervention, and again there was no way to determine which patients would and which would not have recovered spontaneously. At the time of operation on any of these four patients, we would not have been surprised to have found the nerve in question completely divided or to have found it impinged between the fragments of bone. The neurolysis that was performed may well have hastened recovery or prevented more permanent damage in three patients. Even in the patient who had palsy of three nerves, we must conclude that surgical intervention prevented a more permanent deficit.

COMMENT

It is essential to recognize the importance of possible neural and vascular injuries in all patients who sustain supracondylar fractures of the humerus. A thorough sensory, motor, and circulatory evaluation must be carried out at the initial examination. An absent radial pulse may return after careful closed manipulation of the fracture or reduction by traction. In two of our patients in whom radial pulsations were absent, the collateral circulation was sufficient. Jones made it clear that in some instances the collateral circulation is sufficient, if given an opportunity to function,—that is, if the collateral arteries are not constricted by dressings or spasm.

However, if along with the first P of pulselessness, the other three P's of pain, pallor, and paralysis are also noted, as emphasized by Griffiths, immediate exploration of the

artery and nerves in the antecubital fossa is indicated. Griffiths stated, ". . . to hope that an ischaemic limb is suffering 'only' from spasm which 'will probably relax' is to court disaster".

It is granted that some surgical procedures will be performed needlessly by adoption of such an attitude. Nevertheless, we are sure that it is better to perform such operations on several children, if need be, to save one from the severe crippling of Volkmann's contracture. There is no known method to distinguish those conditions in which such deformities will occur from those in which an adequate circulation will develop during the first six to twenty-four hours after reduction of the fracture. If one waits for this period to observe the child, the golden opportunity for prevention of crippling will have been lost.

The value of block of the stellate ganglion with procaine should be emphasized. This aids in the release of spasm of the brachial artery and in the establishment of collateral circulation. Leriche has stated that resection of the injured segment of a persistently spastic or thrombosed brachial artery increases the blood flow in the collateral vessels. This was confirmed in our study.

In most cases of injuries to nerves, neurological deficits may be periodically observed after reduction of the fracture, but repeated evaluations of function must be performed. If palsies are still present after three or four weeks with no apparent improvement, then exploration of the nerve is advised.

SUMMARY AND CONCLUSIONS

1. Supracondylar fractures of the humerus in children may be associated with injuries to nerves or blood vessels which are much more serious than the fracture.

2. The early recognition of such complications is imperative.

3. Early and adequate treatment of acute vascular complications is necessary, even though it means surgical exploration of the antecubital fossa and resection of the injured segment of the brachial artery.

4. Adequate and early treatment of acute vascular injuries usually ensures a good prognosis, but delay may lead to serious and permanent disability.

5. Palsies of nerves should be observed for a few weeks after adequate reduction of the fracture. If no improvement has taken place in function of the nerve or nerves in question after this period, surgical exploration is advisable.

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SURGICAL TREATMENT OF SPONDYLOLISTHESIS WITHOUT SPINE FUSION

Excision of the Loose Lamina with Decompression of the Nerve Roots *†

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The prevalent concept of the cause of symptoms in spondylolisthesis is based upon the belief that, because of the defect in the pars interarticularis of the fifth lumbar vertebra, there is instability at the lumbosacral junction and thereby a tendency for progressive forward slipping of the vertebral body. Fusion has been the accepted treatment because fixation of the lower segments of the spine upon the sacrum would seem to be the rational method of correcting instability and preventing forward displacement. This treatment has long been advocated, even though it is extremely difficult to achieve fusion consistently in this condition.

The concept of instability, however, fails to explain the clinical course often seen in these patients. X-rays made for other conditions sometimes reveal a second-degree or third-degree spondylolisthesis in a patient with no pain in the back or lower extremities. In many patients in the third, fourth, or fifth decade of life, with no previous back symptoms, difficulty develops without injury, or after only trivial injury, and the x-rays reveal a first-degree or second-degree spondylolisthesis. Patients with these so-called "unstable backs" have been able to work for many years at the hardest kind of physical activity until something suddenly starts the train of symptoms.

The concept of instability also fails to explain the recorded observations in the literature. Progressive displacement may occur in children, or rarely in adults, as the result of a severe injury, with immediate displacement from fracture through the transverse processes and articulations with tearing of the annulus. If the symptoms were due to displacement alone, pain would be most marked during early childhood. This, however, is not the case. Furthermore, in the large series of Friberg [1, 2] there has been no correlation between the degree of forward displacement and the degree of the symptoms.

Our interest in this condition was awakened in October 1949. In a young woman a severe sciatica developed following a hyperextension injury. The x-rays showed a first-degree spondylolisthesis. The sciatic pain became worse and the right Achilles reflex became depressed. A herniated disc was suspected but not found on exploration of the fifth lumbar interspace; however, on the operating table it was noted that on hyperextension the mobile lamina of the fifth lumbar vertebra rocked distally, causing traction on the first sacral nerve roots. For this reason the fifth lumbar lamina was excised and a lateral fusion was performed, extending from the sacrum across the pedicle of the fifth lumbar vertebra into the articulation between the fourth and fifth lumbar vertebrae. The patient had considerable relief of the lower-extremity pain until further injury and the development of a pseudarthrosis.

Shortly thereafter another patient with spondylolisthesis was seen, with sciatic radiation, and with definite evidence of compression of the fifth lumbar root. On removal of the mobile lamina of the fifth lumbar vertebra, the fifth lumbar root was seen to be

* This material was presented by the authors in an exhibit at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 1953. Their theories as to the cause of symptoms and the method of operative treatment were illustrated. In addition, a motion picture was shown at the same meeting, demonstrating the complete operative technique.

† Paper presented at the Annual Meeting of The American Academy of Orthopaedic Surgeons, Chicago, Illinois, January 27, 1954. Manuscript received for publication February 5, 1954. Revision received September 13, 1954; second revision received January 31, 1955.

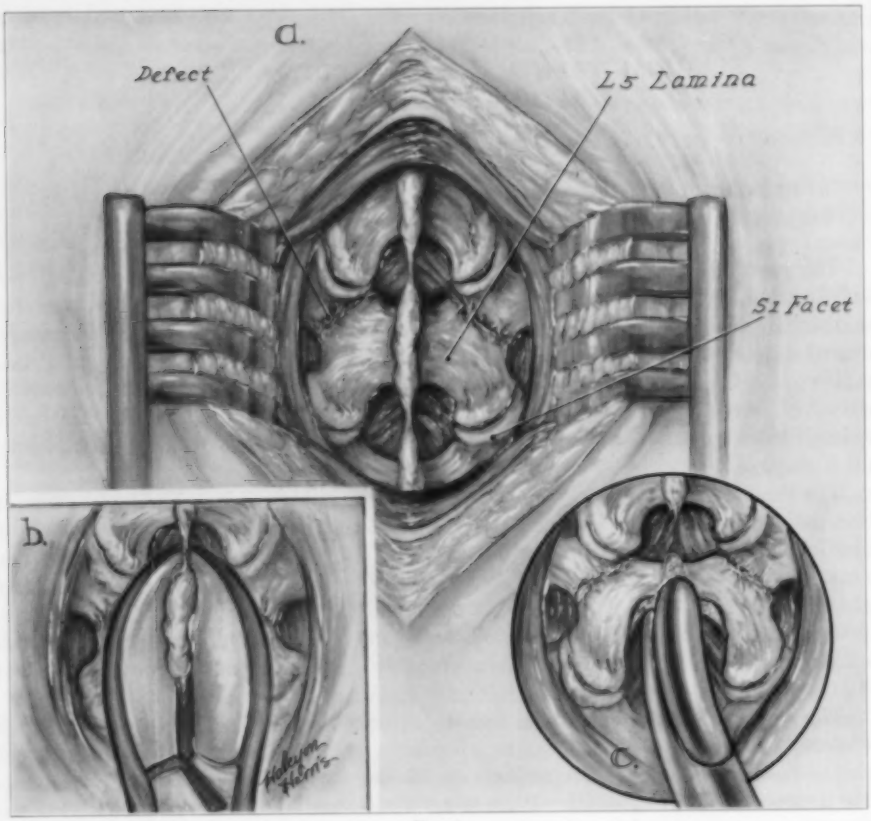

FIG. 1

The lumbosacral area in spondylolisthesis as viewed at surgery. *a*, exposure of the lamina of the fifth lumbar vertebra, showing the defect in the pars interarticularis of the fifth lumbar vertebra; *b*, excision of the spinous process of the fifth lumbar vertebra; *c*, excision of the central portion of the loose lamina of the fifth lumbar vertebra.

compressed by a mass of fibrocartilaginous tissue at the defect in the pars interarticularis of the fifth lumbar vertebra. After decompression of the roots by removal of the fibrocartilaginous mass, a lateral fusion was performed. There was immediate relief of the sciatic pain and of the neurological symptoms. A third patient, a male, with a similar condition, symptoms, and findings at surgery, was treated in an identical manner, with relief.

Meanwhile, in our second patient local back pain again developed, as well as coccygodynia and pain in the lower extremities associated with tightness in straight-leg raising. Re-exploration showed that the bone grafts had slipped medially, causing formation of adhesions of bone to the dura. Because of this complication, and on the basis of limited experience with excision of the inferior articular processes without fusion in arthritic patients, it was decided that in the next patient a decompression procedure alone should be done and later, if necessary, a lateral fusion could be performed, with greater safety.

This operation was first performed on a physician in June 1950. There was relief of the pain both in the back and in the lower extremities and the patient resumed full activity in three weeks. Since then, in eighteen cases surgery has consisted solely of removal of the loose lamina with complete decompression of the fifth lumbar and the first sacral roots. In five other cases, in which fusion operations had failed to result in either fusion

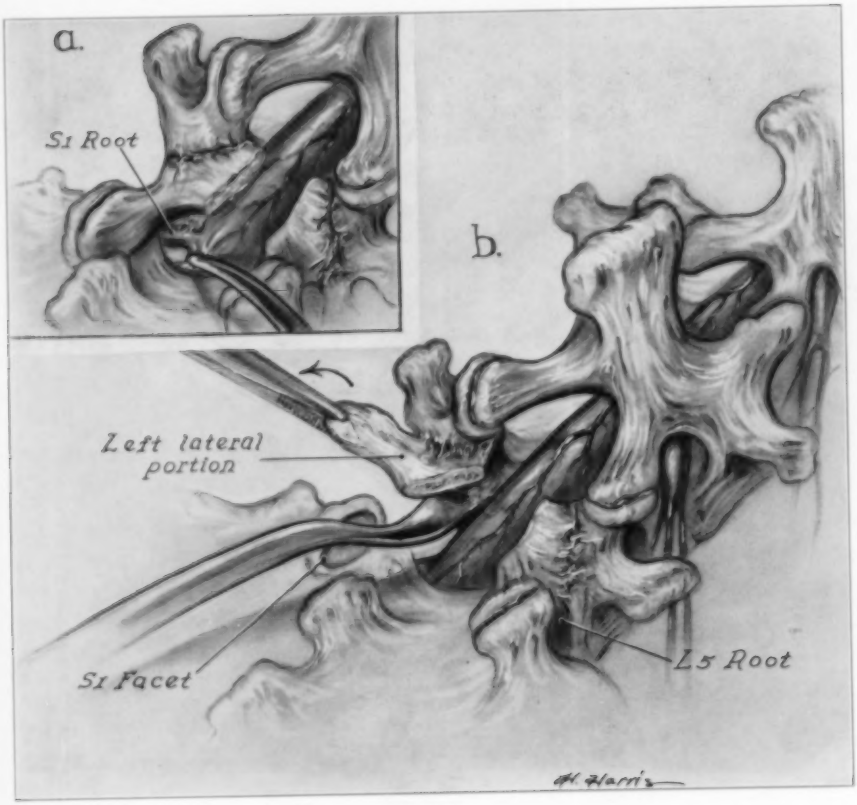

FIG. 2

a: Showing the relationship of the first sacral root to the lateral portion of the loose arch of the fifth lumbar vertebra.

b: Removal of the lateral portion of the loose lamina of the fifth lumbar vertebra.

or relief of symptoms, excision of the fusion mass and of the inferior articular process with decompression of the roots, has given relief. In one other case, despite a conventional and solid fusion, the symptoms persisted until the fibrocartilaginous mass was removed.

Surgical exploration consistently revealed the presence of a fibrocartilaginous mass at the defect in the pars interarticularis of the fifth lumbar vertebra; in some instances this was larger on one side than on the other, but it corresponded in general with the neurological findings.

PATHOLOGY AND SURGICAL PROCEDURE

The patient is placed prone upon the operating table with bolsters extending from the anterior aspect of the shoulder to the anterior superior iliac spine, to allow for full respiration. Flexion is avoided, since this increases the abdominal pressure and hence the bleeding. Through a mid-line incision the spinous processes of the fourth and fifth lumbar and first sacral vertebrae are exposed subperiosteally (Fig. 1, *a*).

There is great variation in the mobility of the loose lamina of the fifth lumbar vertebra. In some patients the interspinal ligament between it and the fourth lumbar vertebra has been tight and, therefore, the free lamina has not been particularly mobile. In others, the lamina has been exceedingly mobile and, on extension of the spine, sometimes pressed downward upon the mass of fibrocartilaginous tissue at the defect, thus increasing the

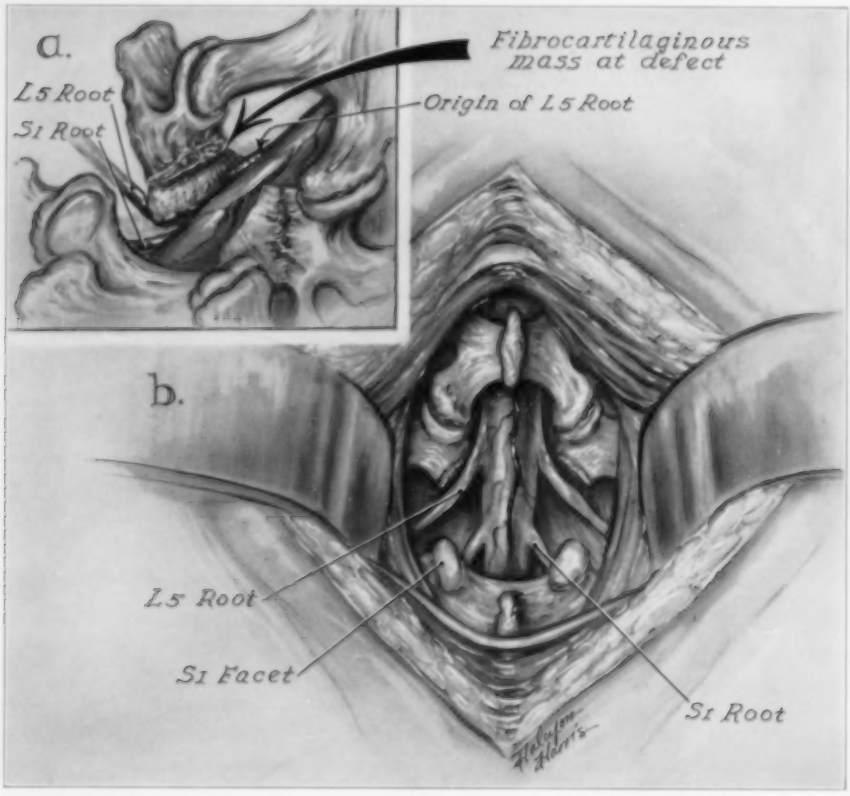

FIG. 3

a: Showing the fibrocartilaginous mass at the defect in the pars interarticularis of the fifth lumbar vertebra after removal of the lateral portion of the loose lamina. The fifth lumbar root is compressed from above, posteriorly, and laterally by the fibrocartilaginous mass.
b: The completed operative procedure.

pressure on the fifth lumbar roots. In still others, the loose lamina rocked downward, causing traction on the first sacral roots at the point where they pass toward the first sacral foramen (Fig. 2,*a*).

Adhesions have frequently been found between the dura and the ligamentum flavum below the inferior margin of the loose lamina of the fifth lumbar vertebra. There has been a definite correlation between this condition and the symptoms of coccygeal pain which these patients sometimes exhibit. Two patients who had had coccygectomy without relief of their coccygodynia were relieved by this procedure.

The spinous processes of the fourth and fifth lumbar and first sacral vertebrae are then excised, since we have found that, if they are left intact, they cause local tenderness postoperatively (Fig. 1, *b*). With the blunt-nosed double-action rongeur, the entire middle portion of the loose lamina of the fifth lumbar vertebra is then removed (Fig. 1, *c*). The inferior aspect of the lamina of the fourth lumbar vertebra is then bitten away again with the blunt-curved double-action rongeur, until the ligamentum flavum is freed from its inferior aspect. By sharp dissection down the mid-line and upward laterally, the interlaminar portion of the ligamentum flavum between the fourth and fifth lumbar vertebrae is excised to afford better exposure. A close relationship between the lateral portion of the loose lamina and the first sacral root is seen (Fig. 2, *a*). The lateral portion of the

loose arch of the fifth lumbar vertebra is then removed, the attached inferior articular process being freed by sharp dissection from its articulation with the sacrum. This fragment is then elevated and is dissected free from the defect in the pars interarticularis, the dissection being done close to the lamina to avoid injury to the fifth lumbar root (Fig. 2, *b*). The fifth lumbar root is exposed somewhat cephalad and is retracted, together with the dura, toward the mid-line, away from the lateral wall and from the defect in the pars interarticularis. The defect is almost invariably found to be filled with a mass of fibrocartilaginous tissue compressing the fifth lumbar root (Fig. 3, *a*).

The fifth lumbar root crosses the disc between the fourth and fifth lumbar vertebrae; in its path toward the intervertebral foramen it lies underneath and is compressed from its lateral and posterior aspects by this mass of fibrocartilaginous tissue. Histologically, the mass is a typical pseudarthrosis composed of fibrocartilaginous tissue and some bone formation.

In most instances the root is found to be adherent to this mass and is covered with large blood vessels. These are carefully divided and the root is dissected free, the cartilaginous mass being removed until the root is free through the intervertebral foramen (Fig. 3, *b*). At times the root is still tight and additional bone must be removed from the pedicle to allow freedom of the root.

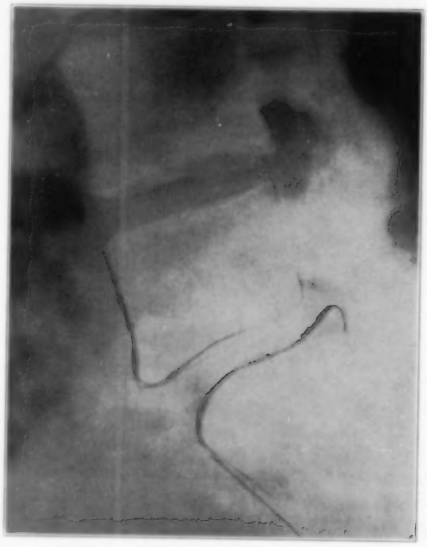

FIG. 4-A

FIG. 4-B

FIG. 4-C

Fig. 4-A: Case 4. Preoperative roentgenogram. (The roentgenogram has been retouched.)
Fig. 4-B: Roentgenogram made forty-two months after operation.
Fig. 4-C: Roentgenogram made fifty-six months after operation.

In some patients an additional bony fragment is present at the defect. This is most clearly shown in the preoperative roentgenograms made in an anteroposterior direction and with the tube at a 20-degree angle toward the head.

The fourth and fifth lumbar discs are then exposed. In only two of our cases have we found bulging of the fourth lumbar disc. If pathological changes are present, the disc is excised. A protrusion at this level would certainly increase the compression of the fifth lumbar root, since it would then be impinged upon superiorly and anteriorly by the disc, and inferiorly and laterally by the fibrocartilaginous mass at the site of the pseudarthrosis. There would seem to be no reason why patients with spondylolisthesis should not be as liable to experience degeneration, herniation, or protrusion as others of the same age, subjected to the same stresses.

FIG. 5-A

We have heard of instances of posterior protrusion or herniation of the lumbosacral disc, but thus far we have never seen one. It is obvious that, as the lumbosacral disc degenerates, the nucleus pulposus is usually pushed forward. We have been struck by the small amount of motion usually present between the fifth lumbar vertebra and the sacrum; the early degeneration and the forward displacement of the nucleus pulposus must account for the marked limitation of motion.

FIG. 5-B

FIG. 5-C

Fig. 5-A: Case 5. Roentgenogram made sixty-two months before operation.

Fig. 5-B: Roentgenogram made three months after operation.

Fig. 5-C: Roentgenogram made thirty-eight months after operation. There is apparent forward displacement of the body of the fifth lumbar vertebra due to further degeneration and narrowing of the lumbosacral disc. The distance between the posterosuperior margin of the body of the sacrum and the postero-inferior margin of the body of the fifth lumbar vertebra has remained the same.

FIG. 6-A

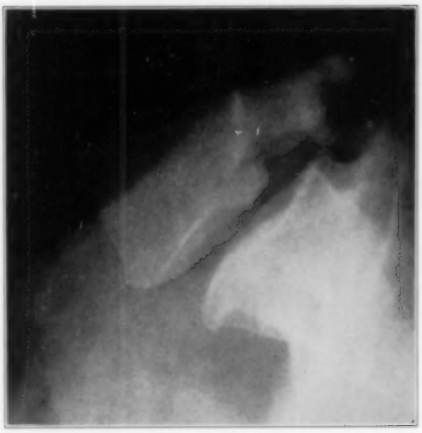

FIG. 6-B

Fig. 6-A: Case 6. Preoperative roentgenogram. (The roentgenogram has been retouched.)

Fig. 6-B: Roentgenogram made thirty-seven months after operation. There is apparent forward displacement due to narrowing of the intervertebral disc. The distance from the posterosuperior margin of the sacrum to the posteroinferior margin of the fifth lumbar vertebra has remained the same. (The roentgenogram has been retouched.)

In one patient with a third-degree spondylolisthesis the fifth lumbar root was compressed at the entrance to the intervertebral foramen between the ledge formed by the margin of the sacrum and the annulus of the lumbosacral disc inferiorly, and the free inferior articular process of the loose lamina of the fifth lumbar vertebra posteriorly (Fig. 14-A). The first sacral roots were also adherent to the annulus of the lumbosacral disc.

FIG. 7-A

FIG. 7-B

Fig. 7-A: Case 7. Preoperative roentgenogram. (The roentgenogram has been retouched.)

Fig. 7-B: Roentgenogram made thirty-five months after operation. (The roentgenogram has been retouched.)

FIG. 8-A

FIG. 8-B

Fig. 8-A: Case 8. Preoperative roentgenogram.

Fig. 8-B: Roentgenogram made thirty-four months after operation. (The roentgenogram has been retouched.)

This mechanism would appear to be present only in those patients with marked forward displacement of the body of the fifth lumbar vertebra.

If the involved vertebra is at a higher level, the same procedure is performed at that level; the corresponding roots at the higher level are involved and are decompressed in the same manner.

When the decompression is completed on each side, the wound is thoroughly irrigated with copious amounts of cool saline. All bleeding points are coagulated. Closure is then accomplished in the usual manner. A relatively thin dressing is applied, in order to allow more comfort after the operation while the patient is supine. Blood is given throughout the procedure.

No support is used at any time during the postoperative period. For the first two or three days the patient experiences a moderate amount of pain in the back. He is encouraged to lie in any position and to move about; he may sit up as soon as he is able to do so. On the third day he is ambulatory and straight-leg-raising exercises are begun, the patient lifting each lower limb four or five times hourly. If by the fifth day straight-leg raising is restricted to less than 75 degrees, an epidural injection through the caudal foramen is carried out.

Under local 1 per cent. procaine anaesthesia, or preferably 0.5 per cent. xylocaine, with the patient on his abdomen, a No. 22 or No. 20 spine needle is carefully inserted into the caudal foramen and passed upward its entire length. The stylet is then removed to make certain that spinal fluid does not escape, after which a solution of approximately 40 to 60 cubic centimeters of 0.2 per cent. procaine or 0.2 per cent. xylocaine containing 0.5 cubic centimeter of hydrocortisone to each 10 cubic centimeters of solution is injected at a speed which can be tolerated by the patient. The injection of the solution will often reproduce the pain in the back and lower extremities. After allowing four or five minutes for a mild hypo-aesthesia to be produced, a forceful straight-leg-raising manipulation is done. This is moderately painful, but the sharp edge of pain is relieved by the analgesia. After this the patient must carry out straight-leg-raising exercises with diligence.

A completely free range of straight-leg raising is most important; we believe that this prevents, or minimizes, the formation of root adhesions, the most common complication following surgery in this area. This is a definite symptom complex which is evidenced by (1) attacks of catching pain in the back or in the buttocks, (2) limitation of

FIG. 9-A

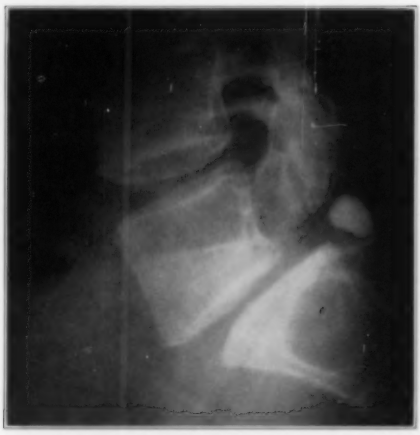

FIG. 9-B

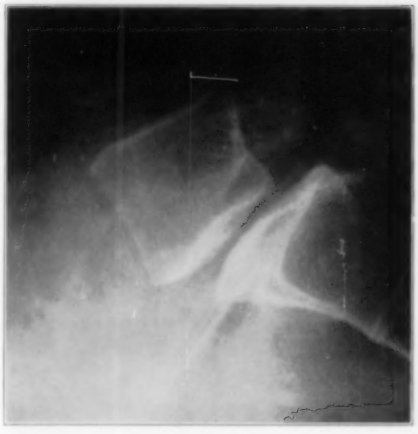

FIG. 9-C

Fig. 9-A: Case 10. Preoperative roentgenogram.

Fig. 9-B: Roentgenogram made eighteen months after operation, showing narrowing of the lumbosacral disc, with settling and apparent posterior progression. There has been no increase in the distance from the posterosuperior margin of the sacrum to the postero-inferior margin of the fifth lumbar vertebra.

Fig. 9-C: Roentgenogram made thirty-three months after operation. There has been no change in the narrowing of the lumbosacral disc and no forward progression.

straight-leg raising on the affected side, (3) spasm on forward flexion with deviation to the involved side, in order to avoid stretching of the affected sciatic root, and (4) a list to the painful side on standing. When this symptom complex is present, rest or immobilization only makes the condition worse. Activity, especially straight-leg-raising and toe-touching exercises, is indicated. If straight-leg raising does not continue to be free—that is, if the limb does not reach at least 90 degrees—the epidural injection may be repeated at two-week intervals.

If the patient is of dark complexion or of the type in whom keloid develops, deep x-ray therapy is started on the third day after surgery. Approximately 1,000 roentgen units are given in three doses, at three-day intervals.

We feel that heavy work should not be done before the sixth to eighth week after surgery, in order to allow firm and quiet healing of the wound.

RADICULAR SYMPTOMS AND FINDINGS

The majority of our patients with symptomatic spondylolisthesis present radicular symptoms. A review of the literature revealed that this occurs in at least two thirds of the patients. In our experience, this may be in the nature of pain in the buttocks and the posterior aspect of the thigh, but it may be a severe sciatica with radiation into the calf, lateral aspect of the heel, the great toe, and the ball of the foot. In some there is coccygeal pain. We believe that the incidence of radiating pain is apparently related directly to the interest of the examiner.

Careful neurological examination in the majority of these patients has revealed in-

FIG. 10-A

FIG. 10-B

Fig. 10-A: Case 11. Preoperative roentgenogram.

Fig. 10-B: Roentgenogram made thirty-two months after operation.

volvement of the fifth lumbar root, either unilateral or bilateral. In about half there has been involvement of the first sacral root. In spondylolisthesis of the fourth lumbar on the fifth lumbar vertebra, the fourth or fifth roots are involved, as would be expected.

The findings in involvement of the fifth lumbar nerve root are weakness of extension

FIG. 11-A

FIG. 11-B

Fig. 11-A: Case 12. Preoperative roentgenogram, showing a first-degree spondylolisthesis with Schmorl's nodules and osteochondritis above the spondylolisthesis. (The roentgenogram has been retouched.)

Fig. 11-B: Roentgenograms made thirty-one months after operation.

FIG. 12-A

FIG. 12-B

Fig. 12-A: Case 13. Preoperative roentgenogram. (The roentgenogram has been retouched.)

Fig. 12-B: Roentgenogram made twenty-five months after operation. (The roentgenogram has been retouched.)

of the great toe with hypo-aesthesia of the tip or the dorsomedial aspect of the great toe. The findings in involvement of the first sacral nerve root are decreased or absent heel jerk with decreased sensation over the lateral aspect of the heel. Forceful stretching of the patient on the table with his knees extended, for five minutes, will often reveal findings of involvement of the fifth lumbar root. Hyperextension for the same period of time is more apt to demonstrate involvement of the first sacral root, but in some patients may demonstrate involvement of the fifth lumbar root.

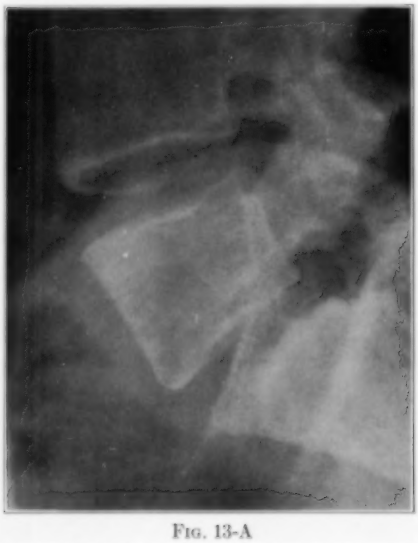

FIG. 13-A

FIG. 13-B

Fig. 13-A: Case 14. Preoperative roentgenogram. (The roentgenogram has been retouched.)

Fig. 13-B: Roentgenogram made twenty-three months after operation. (The roentgenogram has been retouched.)

FIG. 14-A

FIG. 14-B

Fig. 14-A: Case 15. Preoperative roentgenogram, showing a third-degree spondylolisthesis. X-rays made at the extremes of motion showed no movement of the fifth lumbar vertebra on the sacrum.

Fig. 14-B: Roentgenogram made twenty-one months after operation. There has been no change in the position of the fifth lumbar vertebra on the sacrum. (The roentgenogram has been retouched.)

DISCUSSION AND RESULTS

Analysis has been made of all patients treated by decompression and followed for at least one year. These have been divided into two groups: (1) those treated initially by excision of the loose arch and decompression alone (Tables I-A, I-B, I-C, I-D, I-E, and I-F); and (2) those patients who had had previous unsuccessful attempts at fusion and were treated by decompression consisting in excision of the entire fusion mass and excision of the inferior articular process (Tables II-A, II-B, II-C, II-D, II-E, and II-F).

FIG. 15-A

Case 16. Preoperative roentgenogram.

FIG. 15-B

Roentgenograms made twenty months after operation.

TABLE I-A

SYNOPSIS OF CASES OF SPONDYLOLISTHESIS (FIFTH LUMBAR VERTEBRA ON THE SACRUM) ORIGINALLY TREATED BY EXCISION OF THE LOOSE ARCH AND DECOMPRESSION ALONE

Case	Sex	Age	Occupation	Onset with Injury	Duration of Symptoms	Length of Conservative Treatment	Degree of Displacement	Associated Congenital Anomalies	Degree of Preoperative Disability*
4	M	41	Physician	No	5 years	5 years	First	None	Total
5	F	30	Housewife	No	5 years	4 years	First	None	Moderate
6	M	37	Salesman	No	2 years	18 months	First	Bifid lamina of lumbar 5 with fusion to spinous process of sacral 1. Spina bifida occulta of sacral 1.	Moderate
7	F	23	Housewife and secretary	No	2 weeks	None	First	None	Total
8	M	37	Laundryman	No	9 years	9 years	First	Spina bifida occulta of sacral 1.	Total
10	F	44	Housewife	No	14 years	10 years	First	None	Moderate
11	F	27	Secretary	Yes	16 months	16 months	Spondylolysis	Lumbar scoliosis	Moderate
12	F	27	Housewife	No	4 years	1 year	First	Bifid lamina of lumbar 5. Spina bifida occulta of sacral 1.	Moderate
13	M	35	Floor-covering contractor	Yes	Many years. Worse past 15 months	4 months	Spondylolysis	Spina bifida occulta of sacral 1 with fusion of spinous processes of lumbar 5 and sacral 1.	Total
14	M	19	Clerk and laborer	Yes	4 months	1 month	First	None	Moderate
15	F	24	Housewife	No	2 years	18 months	Third	None	Total
16	F	25	Clerk	Yes	7 months	7 months	First	None	Moderate
19	M	23	Medical student	No	Several years	10 months	First	Spina bifida occulta of sacral 1.	Moderate
20	M	40	Teamster	No	2 years	1 year	Second	None	Moderate

* *Total:* unable to carry out any activities; severe back or lower-extremity pain. *Moderate:* unable to carry out most activities; moderate back or lower-extremity pain. *Mild:* able to carry out most activities; mild pain in the back or lower extremities.

TABLE I-B

COMPARISON OF SYMPTOMS AND FINDINGS BEFORE AND AFTER SURGERY

Case No.	Preoperative				Postoperative			
	Back Pain	Area of Radicular Pain	Abnormal Physical Findings	Nerve Roots Involved	Back Pain	Area of Radicular Pain	Abnormal Physical Findings and Remarks	Nerve Roots Involved
4	Moderate	Sciatica on left, severe.	Flexion to 18 in. from floor. SLR* 80° on right, 35° on left.	Left lumbar 5. Sacral 1, moderate.	Mild, occasional	Left thigh, occasional, mild.	Extension slightly restricted and painful. Flexion to 8 in. from floor. SLR 75° bilaterally.	Left lumbar 5 to sacral 1, mild.
5	Moderate	Calves, severe.	Extension painful and restricted.	Left lumbar 5, moderate.	None	None	None. Touches floor.	None
6	Mild	Buttocks. Sciatica on left, severe.	Flexion to 6 in. from floor. Extension painful and restricted. SLR 80° on right, 60° on left.	Left lumbar 5. Sacral 1, moderate.	None	Right calf, occasional, mild.	Flexion to 4 in. from floor.	None
7	Moderate	Buttocks, severe.	Flexion to 4 in. from floor. Extension restricted and painful.	Right lumbar 5, moderate.	None	None	None. Touches metacarpal heads to floor.	None
8	Severe	Right buttock, severe.	Flexion to 18 in. from floor. Right list. Extension painful and restricted. SLR 10° on right, 60° on left.	Right lumbar 5 and sacral 1, moderate.	None	None	None. Flexion to 3 in. from floor.	None
10	Moderate	Sciatica and coccygeal pain on right, moderate.	Extension painful and restricted. SLR 60° on right, 90° on left.	Right lumbar 5 and sacral 1, moderate.	Mild, occasional	None	None. Flexion to 2 in. from floor.	None

TABLE I-B (*Continued*)

11	Mild	Sciatica on left, severe.	Flexion to 10 in. from floor. Extension restricted and painful.	Left lumbar 5 and sacral 1, moderate.	None	Right thigh and buttock, moderate.	Flexion to 12 in. from floor. SLR 60° on right, 75° on left.	None
12	Severe	Sciatica on left, severe.	Extension restricted and increased radicular pain and neurological findings.	Left lumbar 5, moderate.	None	None	None. Touches floor.	None
13	Severe	Right buttock. Sciatica, moderate.	Extension restricted and increased radicular pain and neurological findings.	Lumbar 5, moderate, sacral 1, mild, right.	Mild on heavy lifting only.	Left calf, occasional, mild.	None. Touches floor.	None
14	Moderate	Right buttock. Sciatica, moderate.	Extension restricted and increased radicular pain and neurological findings.	Lumbar 5, bilaterally, moderate. Sacral 1 on right, mild.	None	None	None. Touches floor.	None
15	Severe	Posterior aspect of thighs, severe.	Flexion to 18 in. from floor. Extension restricted and painful. SLR 80° on right, 70° on left.	Lumbar 5, bilaterally, severe. Sacral 1 right, mild.	None	Calves, occasional, mild.	None. Flexion to 2 in. from floor.	Lumbar 5 left, moderate.
16	Moderate	Lateral aspect of right calf, severe.	Extension painful and restricted.	Lumbar 5, right, moderate.	None	Right calf, occasional, mild.	None. Can touch metacarpal heads to floor.	None
19	Mild	Sciatica on right, severe.	Flexion to 2 in. from floor. SLR 60° on right, 80° on left.	Sacral 1, right, moderate.	None	None	None. Flexion to 4 in. from floor. SLR 80° bilaterally.	None
20	Moderate	Left buttock, moderate.	None	Lumbar 4 and lumbar 5, left, mild.	None	None	None. Touches floor.	None

* SLR: straight-leg raising.

TABLE I-C

CORRELATION OF SURGICAL FINDINGS WITH PREOPERATIVE NEUROLOGICAL FINDINGS

Preoperative Findings		Surgical Findings			
Case No.	Nerve Roots Involved	Mobility of Free Lamina	Fibrocartilaginous Mass	Loose Ossicle at Site of Pseudarthrosis	Disc Protrusion
4	Left lumbar 5 and sacral 1, moderate.	Marked	Bilateral	Left	None
5	Left lumbar 5, moderate.	Moderate	Bilateral, larger on left.	None	None
6	Left lumbar 5 and sacral 1, moderate.	Marked	Bilateral, larger on left.	None	Protrusion of lumbar 4 on left.
7	Right lumbar 5, moderate.	Marked	Bilateral, larger on right.	Left	None
8	Right lumbar 5 and sacral 1, moderate.	Marked	Bilateral, larger on right.	None	Protrusion of lumbar 4 on right.
10	Right lumbar 5 and sacral 1, moderate.	Marked	Bilateral, larger on right.	None	None
11	Left lumbar 5 and sacral 1, moderate.	Marked	Bilateral, larger on left.	None	None
12	Left lumbar 5, moderate.	Marked	Bilateral, larger on left.	None	None
13	Right lumbar 5, moderate, sacral 1, mild.	Marked	Bilateral, larger on right.	None	None
14	Lumbar 5 bilaterally, moderate. Right sacral 1, mild.	Marked	Bilateral	None	None
15	Lumbar 5 bilaterally, severe. Right sacral 1, moderate.	Slight	Bilateral, larger on right.	None	None
16	Right lumbar 5, moderate.	Marked	Bilateral	None	None
19	Right sacral 1, moderate.	Marked	Bilateral, larger on right.	None	None
20	Left lumbar 4 and lumbar 5, mild.	Slight	Bilateral, larger on left.	None	None

In the first group there were fourteen cases. Back pain was present in all cases, but in three it was mild and sciatica was the presenting and disabling symptom. In those cases in which back pain was moderate, sciatica was the most marked symptom. Every patient had radicular pain which varied from coccygodynia or pain in the buttocks to radiation into the thigh or calf, or typical sciatic radiation into the heel or into the great toe. Positive neurological findings were present in all cases, usually showing involvement of the fifth lumbar and first sacral roots, the findings being most pronounced on the side of the most severe sciatic pain.

The postoperative follow-up ranged from sixteen to fifty-six months, with an average of thirty months. Back pain was present after surgery in only three cases; in each instance it was occasional and mild, and in one case it was present only on heavy lifting. Radicular pain was more frequent, being present mildly and occasionally in the calf or thigh in five instances. In only one case (Case 11) was it moderate in the right thigh and buttocks; however, this patient had no back pain. In only two cases was there both occasional and mild back and lower-extremity pain (Cases 4 and 13). In only one case was there mild back pain without radicular pain. There were four cases with occasional mild lower-extremity pain without back pain. The operation improved the range of motion of these patients, except in one case (Case 11), in which there was a complication of an epidural cyst with scarring about the root.

TABLE I-D
STUDY OF HOSPITALIZATION, DISABILITY, AND COMPLICATIONS

Case No.	Length of Hospitalization (*Days*)	Length of Disability (*Months*)	Complications
4	7	1	None
5	7	3	Hematoma
6	9	1	None
7	7	1.5	None
8	7	1	None
10	10	2 *	None
11	11	10	Epidural cyst **
12	6	1	None
13	12	6	None ***
14	6	1.5	None
15	9	2	None
16	7	1.5	None
19	11	1	None
20	7	2	None
	Average: 8.2 days	Average: 2.4 months	

* Unable to do housework.
** At re-exploration an epidural cyst was found, as well as scar about the fifth lumbar root. The cyst was due to needle puncture at myelography.
*** Length o disability increased because fusion of the second to the third lumbar vertebra was performed at the time of the decompression procedure for a compression fracture of the second lumbar vertebra.

The preoperative neurological findings have been completely relieved in all but two cases (Cases 4 and 15). This operation has, therefore, usually relieved the pre-existing neurological deficit.

In every instance the patients have been able to return to their preoperative occupations. Five of the men carry out work which can be considered as extremely heavy. One woman has been through two pregnancies with much less discomfort than ever before, and is asymptomatic. Two women carry out full-time outside work in addition to their housework.

In none of the cases has there been further forward displacement of the involved vertebra upon the sacrum (Table I-E). In three instances (Cases 5, 6, and 10) there has been apparent forward displacement of two to three millimeters through settling due to narrowing of the lumbosacral disc, but measurement by superimposition of the preoperative and postoperative roentgenograms clearly showed that the distance from the postero-superior margin of the body of the sacrum to the postero-inferior margin of the body of the fifth lumbar vertebra had not changed.

The results and the classification of results are given in Tables I-E and I-F.

In one case (Case 11), considered unsatisfactory because of the necessity of re-exploration, the patient has returned to work. She has no back pain and only moderate radicular pain in the posterior aspect of the thigh on the right. According to the classification, and except for the re-exploration, she would be considered to have a fair result.

Four patients treated by decompression who had had previous attempts at spine fusion without success have been followed for at least one year (Tables II-A, II-B, II-C, II-D, II-E, and II-F). In only one case (Case 1) was the fusion performed by us, and in this case there was excision of the loose arch only, without exposure of the fifth lumbar root. The fusion was accomplished by an H-graft with the use of additional iliac bone placed laterally about the articular processes.

In each case there was a pseudarthrosis between the fourth and fifth lumbar vertebrae, and between the fifth lumbar vertebra and the sacrum. There was very little motion

FIG. 16-A

FIG. 16-B

Fig. 16-A: Case 19. Preoperative roentgenogram. (The roentgenogram has been retouched.)
Fig. 16-B: Roentgenogram made twenty months after operation.

between the vertebrae, and in two instances this was perceptible only after removal of about 0.6 centimeter of the fusion mass. At surgery the amount of motion was so slight that it alone could scarcely be the cause of the patients' symptoms. In two cases the fusion mass had overgrown the lamina and had sunk in, causing compression of the dura. In one other, ligamentum flavum which had remained following a previous exploration had formed a mass causing dural compression.

FIG. 17-A

FIG. 17-B

Fig. 17-A: Case 20. Preoperative roentgenogram showing a second-degree spondylolisthesis.
Fig. 17-B: Roentgenogram made sixteen months after operation.

TABLE I-E

SYNOPSIS OF RESULTS

Case No.	Occupation	Ability to Resume Former Occupation	Further Forward Displacement	Result	Length of Follow-up (*Months*)	Remarks
4	Physician	Complete. Spends long periods in surgery daily.	None	Fair	56	Improved on heavy exertion (mountain climbing and skiing).
5	Housewife	Complete	None; settling due to narrowing of lumbosacral disc.	Asymptomatic	38	Two pregnancies; the first delivery 12 months after surgery.
6	Salesman	Complete	None; settling due to narrowing of lumbosacral disc.	Good	37	Drives 2,000 miles each month.
7	Housewife and secretary	Complete	None	Asymptomatic	35	In addition to own housework, carries out full-time secretarial position.
8	Laundryman	Complete	None	Asymptomatic	34	Works lifting heavy laundry bags.
10	Housewife	Complete	None; settling due to narrowing of lumbosacral disc.	Good	33	In addition to own housework has taken up light industrial work.
11	Secretary	Complete	None	Unsatisfactory	32	Classified as unsatisfactory because of necessity of re-exploration. Has returned to work. No back pain. Moderate radicular pain.
12	Housewife	Complete	None	Asymptomatic	31	Carries out all activities.
13	Floor-covering contractor	Complete	None	Fair	25	Carries out work which requires heavy lifting.
14	Clerk and laborer	Complete	None	Asymptomatic	23	Carries out all activities.
15	Housewife	Complete	None	Good	21	Carries out all activities.
16	Clerk	Complete	None	Good	20	Carries out all activities.
19	Medical student	Complete	None	Asymptomatic	20	Plays tennis in addition to pursuing medical studies.
20	Teamster	Complete	None	Asymptomatic	16	Does heaviest type of lifting.

In each instance, in addition to thorough decompression of the nerve roots by excision of the fusion mass with removal of the remnant of the original loose lamina of the fifth lumbar vertebra and its attached inferior articular process, excision of the inferior articular

TABLE I-F

CLASSIFICATION OF RESULTS IN FOURTEEN CASES INITIALLY TREATED BY EXCISION OF THE LOOSE LAMINA AND DECOMPRESSION

Satisfactory: Able to carry out all activities.	*Satisfactory:* 92.8 per cent.
Asymptomatic: No back or lower-extremity pain.	Asymptomatic: 6 cases, 42.8 per cent.
Good: Mild or occasional lower-extremity or back pain, but not both.	Good: 5 cases, 35.7 per cent.
Fair: Improved, with mild back and lower-extremity pain, or with moderate back or lower-extremity pain, but not both.	Fair: 2 cases, 14.3 per cent.
Unsatisfactory: Unable to carry out all activities. Moderate back and lower-extremity pain, or reoperation.	*Unsatisfactory:* 1 reoperation, 7.1 per cent.

process was performed at the zygapophyseal articulations which had been damaged by previous fusion attempts.

We wish to emphasize that, aside from excision of the loose lamina of the fifth lumbar vertebra and its attached inferior articular process, excision of the inferior articular process at a higher level—that is, between the fourth and the fifth lumbar vertebrae—is not an integral part of the procedure and has been done only in those instances in which previous surgery appeared to have damaged the zygapophyseal articulations.

The length of follow-up extends from seventeen to thirty-two months, with an average of twenty-three months. One patient classified as having an unsatisfactory result (Case 17) complains of a feeling of weakness in the back and mild pain in the right calf. She had been told in previous years that her back was "broken in half". A very difficult home situation may play a part in her symptoms. Findings at physical and neurological examinations were completely negative at the time of writing, but because of the subjective complaints she is classified as having an unsatisfactory result. The result in one other

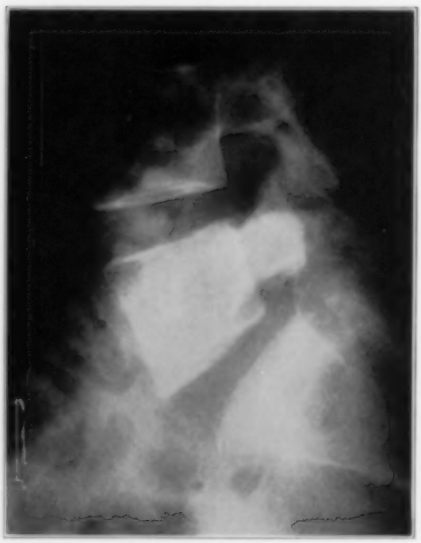

FIG. 18-A

FIG. 18-B

Fig. 18-A: Case 1. Preoperative roentgenogram. Exploration revealed pseudarthroses between the fourth and fifth lumbar vertebrae, and between the fifth lumbar vertebra and the sacrum.

Fig. 18-B: Roentgenogram made twenty-four months after operation, which consisted in excision of the fusion mass and bilateral excision of the inferior articular processes of the third, fourth, and fifth lumbar vertebrae. (The roentgenogram has been retouched.)

SYNOPSIS OF PATIENTS WITH FAILURE OF FUSION TREATED BY EXCISION OF THE LOOSE ARCH AND DECOMPRESSION

Case No.	Age and Sex	Occupation	Duration of Symptoms (*Years*)	Degree of Displacement	Level	Previous Surgery	Degree of Disability
1	21 F	Waitress	6	First	Lumbar 5	Excision of loose arch alone in 1949, with fusion by use of iliac-bone grafts.	Total
9	37 F	Housewife	23	First	Lumbar 5	First spine fusion in 1950, failed. Coccygectomy, 1950. Second spine fusion in 1951, failed.	Total
17	34 F	Housewife	7	First	Lumbar 5	First spine fusion in 1949, failed. Second spine fusion in 1951, failed.	Total
18	24 F	Housewife	12	First	Lumbar 5	Exploration and first spine fusion in 1950, failed. Second spine fusion, 1951, failed. Third spine fusion, 1952, failed.	Total

TABLE II-B

COMPARISON OF SYMPTOMS AND FINDINGS BEFORE AND AFTER SURGERY

	Preoperative				Postoperative			
Case No.	Back Pain	Area of Radicular Pain	Abnormal Physical Findings	Nerve Roots Involved	Back Pain	Area of Radicular Pain	Abnormal Physical Findings and Remarks	Nerve Roots Involved
1	Continuous severe	Both calves; severe on right.	Flexion to 6 in. from floor. Extension limited and painful.	Lumbar 5 and sacral 1 bilaterally, moderate.	Morning stiffness relieved by exercise. Mild back pain after heavy work.	Right calf, occasional, mild.	Touches floor. SLR 90° bilaterally, with tightness on right.	Sacral 1, right, mild.
9	Continuous moderate	Coccygodynia, moderate. Sciatica on left, severe.	Flexion to 5 in. from floor. SLR 90° on right, 70° on left.	Lumbar 5, left, moderate.	Sitting for prolonged periods gives tired feeling.	None	None. Touches floor.	None
17	Continuous severe	Thighs and calves bilaterally, moderate.	Flexion to 5 in. from floor, giving right sciatic pain. Extension limited and painful.	Lumbar 5 bilaterally marked on right.	Feeling of weakness. Extension slightly painful.	Right calf, mild.	None. Touches metacarpal heads to floor.	None
18	Continuous severe	Right buttock. Sciatica, severe.	Flexion to knees. Extension limited and painful, giving right sciatic pain. SLR 70° bilaterally.	Lumbar 5 bilaterally, marked on right. Sacral 1, right, moderate.	Mild low-back pain. Occasional catching. Extension slightly restricted.	Right thigh, mild.	None. SLR 90° bilaterally.	Lumbar 5, right, mild.

TABLE II-C

CORRELATION OF SURGICAL FINDINGS WITH PREOPERATIVE NEUROLOGICAL FINDINGS

Case No.	Nerve Roots Involved before Operation	Level of Pseudarthrosis	Surgical Findings		
			Amount of Motion	Fibrocartilaginous Mass	Dural Compression
1	Lumbar 5 and sacral 1 bilaterally, moderate.	Lumbar 4 and 5 Lumbar 5 and sacral 1	Perceptible only after removal of ¼ in. of bone.	Bilateral, larger on right.	By fusion mass extending over lamina of lumbar 4.
9	Lumbar 5, moderate.	Lumbar 4 and 5 Lumbar 5 and sacral 1	Barely perceptible.	Bilateral, larger on left.	None noted.
17	Lumbar 5, bilaterally, marked on right.	Lumbar 4 and 5 Lumbar 5 and sacral 1	Barely perceptible.	Bilateral, larger on right, with adhesions to lumbar 5 root.	By sinking in of fusion mass.
18	Lumbar 5, bilaterally, marked on right. Sacral 1, right, moderate.	Lumbar 4 and 5 Lumbar 5 and sacral 1	Barely perceptible only after removal of ¼ in. of bone.	Bilateral, larger on right.	By mass of ligamentum flavum below lamina of lumbar 3.

TABLE II-D

STUDY OF SURGERY PERFORMED, HOSPITALIZATION, DISABILITY, AND COMPLICATIONS

Case No.	Surgery	Hospital Stay (*Days*)	Length of Disability (*Months*)	Complications	Findings on Re-Exploration
1	Excision of inferior articular processes at lumbar 3 to 4 and 4 to 5.	18	4	Small pulmonary embolus.	None
9	Excision of inferior articular processes at lumbar 4 and 5.	15	7	None	None
17	Excision of inferior articular processes at lumbar 4 and 5.	7	2	None	None
18	Excision of inferior articular processes at lumbar 4 and 5.	12	2 *	Bone formed in scar, requiring excision in April 1954. Persistent symptoms related to lumbar 5 root requiring re-exploration in September 1954.	Osseous proliferation in scar overlying dural sac. Intraneural scarring of right lumber 5 root. Root sheath was divided.

* Hospitalization was for two months following each procedure.

TABLE II-E

SYNOPSIS OF RESULTS

Case No.	Occupation	Ability to Resume Former Occupation	Further Forward Displacement	Result	Length of Follow-up (*Months*)	Remarks
1	Waitress	Complete	None	Fair	24	Mild and occasional back and lower-extremity pain. Went through recent pregnancy much more easily than ever before.
9	Housewife	Complete	None	Good	32	Occasional and mild back pain only. Carries out all activities.
17	Housewife	Complete	None	Unsatisfactory	19	Complains of weakness of back and mild right calf pain (believed to be very neurotic). Findings minimal. Carries out all activities.
18	Housewife and secretary	Complete	None	Unsatisfactory	17	Mild low-back and right calf pain despite two re-operations for re-formation of bone and scarring. Findings minimal. Carries out all activities.

case (Case 18) is classified as unsatisfactory because two further operative procedures have been performed since decompression. In this patient bone re-formed to some degree in the area from which the fusion mass had been removed. This caused local tenderness requiring its excision; after excision she no longer experienced the local back tenderness. Because of the persistence of some radicular pain and mild symptoms indicating involvement of the fifth lumbar root, another re-exploration was done, with exposure of only the right fifth lumbar root and the splitting of the sheath. The root showed intraneural fibrosis. The patient has been improved by this procedure; although she is still having some mild back pain with occasional catching, the radicular pain in the thigh has been

TABLE II-F

CLASSIFICATION OF RESULTS IN FOUR CASES OF SPONDYLOLISTHESIS WITH FAILURE OF FUSION TREATED BY EXCISION OF THE LOOSE ARCH AND DECOMPRESSION

Satisfactory: Able to carry out all activities. Asymptomatic: No back or lower-extremity pain. Good: Mild or occasional back or lower-extremity pain, but not both. Fair: Improved, with mild back and lower-extremity pain, or moderate back or lower-extremity pain, but not both.	*Satisfactory:* 50 per cent. Asymptomatic: None Good: 1 case, 25 per cent. Fair: 1 case, 25 per cent.
Unsatisfactory: Unable to carry out all activities. Moderate pain in back or lower extremities, or both, or reoperation.	*Unsatisfactory:* 50 per cent. 1 patient had reoperation (minimal symptoms, carries out all activities). 1 patient complains of weakness of back and mild right calf pain (minimal symptoms, carries out all activities).

FIG. 19-A

FIG. 19-B

Fig. 19-A: Case 9. Preoperative roentgenogram, showing a pseudarthrosis at both the fourth and fifth lumbar interspaces following two attempts at spine fusion. (The roentgenogram has been retouched.)

Fig. 19-B: Roentgenogram made thirty-two months after operation, which consisted in excision of the fusion mass and bilateral excision of the inferior articular processes of the fourth and fifth lumbar vertebrae. (The roentgenogram has been retouched.)

considerably relieved. She states that she has been "over 80 per cent. relieved" since the decompression operation, and while before she had been totally disabled, she is now able to do her housework and also holds an outside position.

Of these four patients none has shown further forward displacement between either

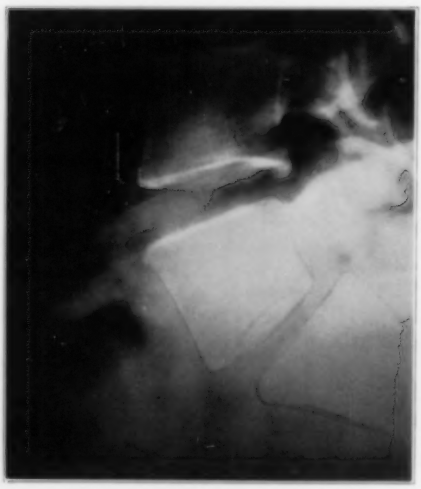

FIG. 20-A

FIG. 20-B

Fig. 20-A: Case 17. Preoperative roentgenogram, showing a pseudarthrosis at the fourth and fifth lumbar interspaces following two attempted fusion operations. (The roentgenogram has been retouched.)

Fig. 20-B: Roentgenogram made nineteen months after excision of the fusion mass and bilateral excision of the inferior articular processes of the fourth and fifth lumbar vertebrae.

FIG. 21-A

FIG. 21-B

Fig. 21-A: Case 18. Preoperative roentgenogram showing a pseudarthrosis at the fourth and fifth lumbar interspaces following three attempted fusion operations. (The roentgenogram has been retouched.)

Fig. 21-B: Roentgenogram made seventeen months after excision of the fusion mass and bilateral excision of the inferior articular processes of the fourth and fifth lumbar vertebrae.

the involved vertebra and the sacrum, or between the vertebrae between which excision of the inferior articular processes had been performed.

In this small group of cases the results are clearly not so good as in the group treated initially by excision of the loose arch; however, the remaining symptoms are primarily those of scar formation. This is understandable in view of the many operative procedures and attempts at fusion which had been carried out, and the surgical findings of scar and pressure on the dura from sinking of the bone grafts. In these patients, the back pain has not been the fundamental disability, and the symptoms primarily indicate scar formation in and about the nerve roots. One of these patients recently went through another pregnancy; she stated that she had had discomfort only during the last two months, and that this had been a much easier pregnancy than any before.

To summarize, back pain following this procedure has been mild, the radicular symptoms constitute the chief remaining cause of pain and disability. In a large measure the procedure has definitely relieved the neurological findings, together with the back pain. It is the authors' opinion that the remaining symptoms are caused by scar about either the dura or the root, causing some slight residual ache and irritation, or by intraneural scar, the result of long continued compression and irritation of the nerve roots by the basic pathological process. It is believed that the results of this procedure will improve as the technique of its performance and the prevention and treatment of postoperative and intraneural scar are improved.

CONCLUSIONS

It seems evident that the removal of the underdeveloped and loose lamina does not increase the so-called "instability" of the lumbosacral junction. If the defect in the pars interarticularis is supposed to cause instability, then the removal of the mobile fragment should not increase the instability. Surely, no surgeon who has examined the loose fragment could believe that it has any function in holding the fifth lumbar vertebra to the sacrum.

Our concept of the pathomechanics of this condition would answer all that is not explained by the prevalent concept of instability at the lumbosacral junction. If the loose lamina is not very mobile, there may be no irritation of the dura. If the defect in the pars interarticularis is more posteriorly situated, pressure on the fifth lumbar root could not develop. Conversely, if the defect were anterior, the likelihood of compression of this root would be greater. This pathological picture also explains why patients go for years without symptoms, since considerable time may be necessary for the growth of a fibrocartilaginous mass large enough to compress and irritate the fifth lumbar root. It would explain, moreover, the sudden development of symptoms following a flexion injury, since the fibrocartilaginous mass would pull upon the adhesions between it and the nerve roots. Of even more importance is the explanation of the susceptibility of these patients to hyperextension injury. The jamming down of the loose lamina causes local irritation of the dura, stretching of the first sacral roots, and a more downward pressure upon the fifth lumbar roots which are already in a precarious condition.

Coccygeal pain may be explained as the result of adhesions between the ligamentum flavum, the inferior edge of the loose lamina, and the dura. Tugging or pulling on these adhesions may give rise to pain in the lumbosacral area and, in many instances, to coccygodynia. That coccygeal pain may result from adhesions about the lower dural sac cannot be doubted, since we have relieved these symptoms by division of the adhesions to the dural sac.

The successful results of the conventional fusion operation may be explained on the basis of the prevention of dural and nerve-root compression and irritation from the mobile lamina, and perhaps by shrinkage of the pseudarthrosis, or of the fibrocartilaginous mass following fixation. Similarly, fusion may give relief in those few cases in which symptoms are arising from protrusion of the fourth lumbar disc.

We do not advise the decompression procedure in children because the rare instances of forward displacement have occurred in this group. We have recently seen a patient, aged eight years, who is already having radicular symptoms, with definite compression of the fifth lumbar root. In this type of case the simple fusion operation would not be likely to give relief. We feel that conservative treatment, consisting in postural exercises and support in the flexed position, should be used until the late teens when growth is completed.

In adults the advantages of the decompression operation are obvious. In addition, many patients who have been unable to afford the long period of disability necessitated by the conventional fusion operation will be able to accept relief.

In conclusion, the authors present the thesis that the majority of patients with symptomatic spondylolisthesis show radicular symptoms in addition to the local ache and tenderness in the lumbosacral area. Careful neurological examination of most of these patients reveals involvement of the fifth lumbar and, in some cases, of the first sacral root. Surgical exploration has consistently revealed nerve-root compression by a mass of fibrocartilaginous tissue at the defect in the pars interarticularis of the fifth lumbar vertebra. Movement of the loose lamina may, in addition, cause nerve-root and dural irritation and compression. Surgical decompression by removal of the loose lamina and the mass of fibrocartilaginous tissue at the defect in the pars interarticularis has given relief, not only of the radicular symptoms, but also of the low-back pain.

REFERENCES

1. Friberg, Sten: Studies on Spondylolisthesis. Acta Chir. Scandinavica, **82** (Supplementum 55), 1939.
2. Friberg, Sten: Spondylolisthesis and Trauma. Svenska Läk.-tidning., **36**: 1379–1382, 1939.

DISCUSSION

Dr. Lee T. Ford, St. Louis, Missouri: Before we had seen the exhibit and movie shown at the 1953 Academy meeting, our group had had no experience with this decompression operation. We had performed

spine fusions in cases of spondylolisthesis in which the symptoms justified surgery and in which response to conservative treatment had been inadequate, and we had been satisfied with the results. In each of the eight cases of spondylolisthesis in which we performed decompression after the manner of Gill and his associates, we found the pathological picture described by them. In two of our eight cases, disc rupture was also present and the displaced disc tissue was removed.

We have not had the difficulty with adhesions which the authors have had. We have not performed epidural injections of novocain or hydrocortone and we have not had to use manipulation in any of these cases. We do not believe that these methods should be used routinely.

This operation will give good relief of sciatic pain due to the presence of a fibrocartilaginous mass when adequate decompression is performed. Our patients have had slight residual low-back pain which has not been disabling. There has been no further forward displacement in any case following removal of the posterior element, although we were quite worried that this might occur. Should disabling low-back pain develop in these patients, or should they show additional displacement in the future, we will advise fusion and can expect such a fusion to be no easy job.

In the roentgenographic examination of these patients we advise making anteroposterior, lateral, and oblique roentgenograms of the lumbosacral spine, since the defect in the pars interarticularis may not always be apparent in the lateral view. Occasionally oblique views made at several different angles may assist in showing the defect. This was brought to our attention several years ago by Colonel Lloyd Taylor.

This condition is of greater importance, and its incidence as a cause of low-back pain with or without sciatica is higher than many realize. Roche and Rowe[a] found an incidence of such defects in the neural arch of 4.2 per cent. in 4,200 skeletons examined by them at Washington University in St. Louis.

We wish to disagree with the authors on the use of the term spondylolysis to indicate the presence of defects in the pars interarticularis without displacement of the body of the vertebra. We have arbitrarily used the term "spondyloschisis" to describe this condition.

Dr. Gill and his associates have provided an operation which, while it is no more effective in relieving symptoms of spondylolisthesis than is a good spine fusion, will relieve symptoms more quickly. It will get the patient on his feet and in most cases enable him to return to his occupation more quickly than is possible after a spine fusion.

a. Roche, M. B., and Rowe, G. G.: The Incidence of Separate Neural Arch and Coincident Bone Variations. A Summary. J. Bone and Joint Surg., **34-A:** 491–494, Apr. 1952.

Dr. Luther M. Strayer, Jr., Bridgeport, Connecticut: Dr. Gill and his co-authors have written an excellent paper; one of the best parts of it is the detailed case reports.

On Dr. Griswold's service at the Bridgeport Hospital we appear not to have had the difficulties that Dr. Gill has had in the severe cases. Only three cases out of sixteen diagnosed in the last ten years have presented symptoms similar to Dr. Gill's cases. In eight of sixteen patients in whom operation was performed the usual fusion procedure immobilizing the posterior elements has given satisfactory results.

Pain leading to removal of the coccyx in two patients preoperatively, that is, before Dr. Gill saw them, and in two patients in his series postoperatively is, I believe, due to the same cause. Dr. Gill emphasizes root irritation preoperatively as the cause of pain. I believe that root irritation postoperatively is the cause of coccygeal pain, and that it is due to the instability following operation in these patients. If it is due to postoperative encroachment upon the dura, I would advise the use of some method for avoiding adhesions. There are many procedures by which this can be done. The use of a piece of fascia to cover the dura before a bone graft is inserted, or preservation of the ligamentum flavum attached to its expansion which can then be laid down over the dura, coagulation of raw bone surfaces with diathermy, the use of bone wax, or placing of fat and areolar tissue around the dura before closure, all are methods which will help. Somehow it happens that we have avoided this complication in our cases of spine fusion without much difficulty.

In our fusion operations the spinous processes are never excised level to the lamina. The cortex of the spinous process is removed, so that the process projects upward into the bone-graft mass and serves as another source of blood supply and primitive connective-tissue cells, thus shortening the time required for the bone-graft mass to consolidate.

I would agree with the authors that the fibrocartilaginous mass from the pseudarthrosis can be a source of nerve-root irritation. We may also agree that the anterior longitudinal ligament is in most cases strong enough to prevent further anterior displacement.

I do not believe that excision of the inferior articular process is necessary. Considerable discussion could be made on this point. Evidence is accumulating from many sources that the bony and cartilaginous elements of joints are not the source of severe pain. The opening up of this raw subperiosteal surface may well cause proliferation of scar tissue and bone fragments, resulting in constriction of the nerve roots postoperatively.

Dr. Gill has had to work very hard for his results. Four of the twenty patients have had two or more operations. I would advise anyone contemplating this procedure to study the excellent case reports in detail. However, it is entirely possible that the principle which Dr. Gill and his associates have worked out so far

may lay the foundation for a satisfactory way to handle the severe case of spondylolisthesis which presents large and unusual defects. A well performed fusion of the posterior elements with careful postoperative supervision is still a good method to handle all the disabling features of this condition except the fibrocartilaginous mass, and the presence of this mass can properly be detected by using the excellent criteria of posterior nerve-root pressure which have been so clearly delineated by Dr. Gill, as contrasted to the anterior pressure syndrome of intervertebral-disc rupture with which we are quite familiar. Once a good fusion which really immobilizes the posterior elements has been effected, the site of the pseudarthrosis should not enlarge.

By his careful clinical and pathological observation and recording, Dr. Gill has presented us with many facts which will aid in the management of spondylolisthesis, and we owe him many thanks for it.

Dr. Gill (closing): We have not used manipulation in these patients. We have performed straight-leg raising only in those patients who after operation have shown clinical evidence of adhesion formation.

Dr. Strayer commented upon the fact that four of these patients had reoperation. Actually, only one of the patients with simple excision of the loose arch has been reoperated upon and exploration may be necessary in another. The patient who had several reoperations was one who had had excision of the arch and a lateral fusion; this is the case which gave us the most trouble and it was because of these difficulties that we stopped doing lateral fusions. Four of our patients had been treated unsuccessfully by conventional fusion, having had one to three operations. They were terribly disabled. Of these four, only one had had a fusion performed by us, the other fusion operations having been done by competent men in renowned clinics in this country. Surgery revealed overgrowth of bone with compression of the dura as a result of the fusion.

In closing, I feel that this procedure makes relief possible for many patients who until now could not afford the six months to a year necessary to obtain solid fusion. Furthermore, even in the best of hands the fusion operation has a rate of pseudarthrosis of about 25 per cent.

Dr. Maurice B. Roche, St. Louis, Missouri (by letter): I would like to take this occasion to voice a plea for proper terminology. There is an increasing tendency to refer to these lesions as "pedicle" defects.

The arch of a vertebra is formed by the two roots (pedicles) and the two laminae and supports seven processes—one spinous, two transverse, and four articular. The region between the body and the superior articular process has been commonly referred to as the root or pedicle, the region between the superior and inferior articular processes as the pars interarticularis, and the portion between the superior articular process and the spinous process as the lamina. Defects may occur in the pedicle, either anterior or posterior to the transverse process, in the pars interarticularis, in the lamina, or in the spinous process.

Bilateral defects through the pedicle and posterior to the transverse process would therefore separate the body of the vertebra and the transverse process *from* that portion of the vertebral arch which includes the superior articular processes, the partes interarticulares, the inferior articular processes, the laminae, and the spinous process. Bilateral defects through the pars interarticularis create a separation of the body of the vertebra, the roots, the transverse processes, and the superior articular processes *from* the inferior articular processes, the laminae, and the spinous process.

It is this latter segment, composed of the inferior articular processes, the laminae, and the spinous process, which apparently is proposed for removal in this presentation. For the sake of avoiding a misconception of the site of this lesion which is under consideration for surgical intervention, and also to avoid confusion in the literature, the difference between the locations of these two lesions is remarked. This was also discussed and illustrated by Stewart[a].

a. Stewart, T. D.: The Age Incidence of Neural-Arch Defects in Alaskan Natives, Considered from the Standpoint of Etiology. J. Bone and Joint Surg., **35-A**: 937–950, Oct. 1953.

THE CARE OF OPEN INJURIES OF THE HAND AND FINGERS WITH SPECIAL REFERENCE TO THE TREATMENT OF TRAUMATIC AMPUTATIONS*

BY PATRICK CLARKSON, F.R.C.S., LONDON, ENGLAND

From the Accident Service, Guy's Hospital, London

This paper describes the treatment of open injuries of the hand and fingers, seen in a teaching hospital the day of the accident. It is concerned principally with the question of primary skin healing and only indirectly with the repair and healing of tendons, nerves, and bone. The total figures shown in Chart I give a fair indication of the volume of work, the distribution of type of injury, and the incidence of complications. The chart indicates the total size of the problem as seen in the Accident Service of Guy's Hospital where about 3,000 of 11,000 accident cases seen in a year are injuries to the hand. In addition to this number, there are something under 1,000 patients who come in with primary hand infections. The Guy's Hospital figures are, therefore, in conformity with the general picture of the distribution of accidents treated in most hospitals serving light industries in densely populated cities. The upper extremity below the elbow is the most commonly injured part of the body, and these injuries account for a third to a half of the total accidents which have to be treated. It is important to note that the great majority of the injuries in this series are small injuries. They comprise any breach of the full thickness of the skin of the hand and fingers. The patients are unscreened, come directly to the hospital without direct payment, and undoubtedly include many who in other countries would not be referred to a hospital, and, indeed, who might have no medical aid at all without a high incidence of complication. Less than 10 per cent. of these patients had fractures, and less than 1 per cent. needed admission to hospital. Only about 200 could be said to have provided repair problems requiring the use of flaps or free grafts. I propose to discuss the method

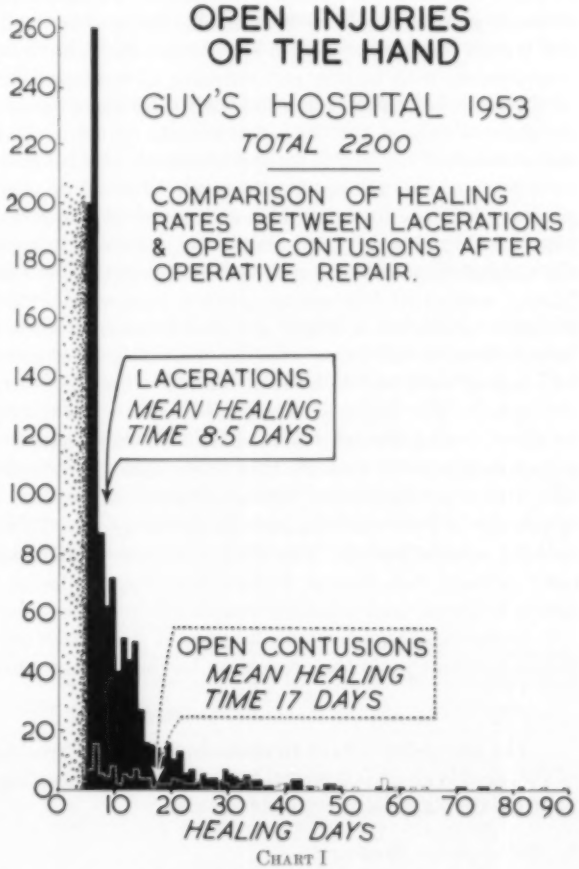

CHART I

* Read at the Annual Meeting of the American Society for Surgery of the Hand, Chicago, Illinois, January 22, 1954.

of treatment adopted under two main headings: (1) the anti-infective measures and (2) the reparative measures.

Before proceeding to discuss treatment, it is necessary to discuss the reasons hand wounds are best considered as belonging to one of two distinct types.

TYPES OF HAND WOUNDS

I believe it is useful to classify hand wounds in accordance with the method or agent of injury and to note that there are two main types, the clinical course and best treatment of which differ. There are on the one hand the injuries due to lacerating violence, such as those caused by cutting instruments, sharp pieces of metal, and glass; on the other hand, there are the breaches of the surface caused by crushing violence. These are the open contusions seen after the hand has been caught in power presses, doors, and hammers. Open contusions are more severe than lacerations of the same extent, not only because of the higher incidence of damage to bone and other deep structures, but because of the progressive oedema to which they are subject for the first twenty-four to forty-eight hours after injury and because of the indeterminate extent of the deep-tissue loss in the early stages. The natural history of these wounds, even under ideal conditions of treatment, is for healing to take two to three weeks. Healing in lacerating injuries may be expected in one week, after full orthodox treatment. The most extreme example of the open contusion type of injury is seen in hands damaged by high-explosive missile wounds. Here the tissues from either side of the missile tracts have been subjected to extreme lateral compression, with tearing and stripping of tendons, vessels, and nerves, and a bursting of the skin cover after it has been blown up like a balloon. In these injuries, the factors of progressive oedema and the indeterminate nature of the loss of tissues in the early stages make closure of the wound by approximation of the edges particularly likely to be followed by serious complications. An alternative method of thin split-thickness skin-grafting for coverage is generally safer. Although many of the open contusions seen in civil practice can be safely closed by approximation, I believe it important in teaching to emphasize the fundamental distinction in the clinical course between the two chief types of injury. Thus I teach that lacerations, given a routine minimal but meticulous excision and an accurate apposition of edges, will heal in about a week and that open contusions should be subjected to full toilet, with the removal only of grossly soiled and obviously devitalized tags of tissue and with suture limited to that necessary to maintain flaps in anatomical position. A split-thickness skin graft is used when the edges do not lie together without tension. Healing for open contusions is slower—that is, in two to three weeks—and the scars are commonly broader than those seen after repair of lacerating injuries. I believe that, unless the distinction between lacerations and open contusions is made, the practice of primary closure can be unnecessarily dangerous. This is particularly true for the high-velocity missile wounds. This view in no way challenges the validity of the principle of early primary skin closure; it does, however, emphasize the need of choice of method if severe ischaemic and infective complications are to be avoided in open contusions.

In the cases reported here, lacerations were about ten times as common as contusions; but in previous years the proportion has been nearer three to one.

TREATMENT

The first point I have to make is that every breach of the full thickness of the skin of the hand is given full formal treatment in an operating theater fully equipped with the appropriate plastic-surgery instruments.

1. *Anti-Infective Measures*

Sera and antibiotics: Tetanus in small injuries is largely a regional risk in England, but I teach that in London tetanus antitoxin should be given to all patients with breaches

TABLE I

CAUSES OF HAND INJURIES AND GENERAL ACCIDENTS (GUY'S HOSPITAL)

	Per cent.
Causes of general accidents	
Industrial	30. to 40.
Traffic	30. to 40.
Domestic	20.
Recreational	10.
Causes of hand injuries*	
Industrial	57.
(Cogs, chisels, power presses, hammers)	
Traffic	3.
Domestic	28.
(Knives, scissors, windows, burns)	
Recreational	12.

* In some industries, such as furniture, metal work, and meat-packing, 90 per cent. of the injuries are hand injuries.

of the surface except those who have had the toxoid in the Services or who have suffered from allergic complaints. Penicillin is only given prophylactically for injuries with gross soiling or when the repair has taken more than an hour and it is considered that a risk of air-borne contamination has existed.

Toilet: We have found it a great practical advantage if the primary toilet is done first by the patient himself. He does this in a 1 per cent. detergent (effective against gram-positive organisms), taking about half an hour to clean the whole limb below the elbow, paying particular attention to the nails. He wears a mask while he does this. After local analgesia has been given, a secondary toilet with a second detergent is done by the operator. This second detergent is used for the secondary toilet because of its effect on gram-negative organisms. Coliform organisms are the only pathogenic contaminates which we find in our wounds.

Local analgesia: Over 99 per cent. of the patients are treated under local analgesia. It may be of interest to note that we have had no trouble in the use of digital-nerve blocks. We have done nearly 15,000 of these without ischaemic or infective complications. The chief precaution in the use of this method is the avoidance of the use of adrenalin.

Excision or débridement: We do a routine minimal excision for lacerations in order to produce non-contaminated, non-beveled edges which can be accurately apposed. We use the term "débridement" to describe the lavage and toilet of the deep layers of the open contusions, which are combined with excision of only grossly soiled or obviously devitalized tissue. Tissue of doubtful viability is left at primary operation.

TABLE II

RESULTS

	Admissions (*Per cent.*)	Infection Rate Major	Infection Rate Minor	Attendances (*Mean*)	Mean Healing Time (*Days*)
1,800 lacerating injuries without soft-tissue loss	0.3	0	6	3.18	8.5
70 lacerating injuries with soft-tissue loss	0.6	0	4	8	27
220 open contusions without soft-tissue loss	1.	0	4	7	17
70 open contusions with soft-tissue loss	1.	0	3	6	21

2. *The Reparative Measures*

Methods of closure available for wounds of the hand are the same as those used elsewhere in the body—that is, by approximation, by free graft, or by flap. In about 90 per cent. of the cases reported here, the method used was simple approximation, with or without undermining. The free grafts that have been used for primary repair have been thin split-thickness skin grafts cut from the forearm in men and from the thigh in women. Occasional use has been made of cross-finger flaps, thenar flaps, and palmar flaps.

RESULTS

Chart I and Table II show the results in this series of injuries reported for 1953. I should like to draw attention to the difference in the healing rates between the lacerations and the open contusions. The lacerations show a mean healing rate of eight days; the open contusions show a mean healing rate of seventeen days. Although the open contusions include more serious injuries, these results do, I think, support my contention that there is a fundamental difference in the natural clinical history and healing rates of the two injuries. Although the mean healing rates of eight days and seventeen days, respectively, may appear to indicate a reasonable general standard of result, the histogram (Chart I) shows that there were many in whom healing was delayed, in some cases for many weeks. The mean healing time of the injuries with soft-tissue loss, whether due to lacerating violence or to crushing injury, was nearly a month. This length of time is capable of very considerable improvement. The infective complications reported may appear low, and it is quite possible that the incidence of minor infections was in fact higher. There happened last year to be no major infections, although we have in the past expected acute infection to develop in about 1 per cent. of the repairs done for out-patients, with pain, fever, pus, and separation of the wound.

TRAUMATIC AMPUTATION OF THE DIGITS

Primary Treatment of Traumatic Amputation of the Digits

I believe the choice of primary method of repair rests between cover of the stump by a thin split-thickness skin graft and cover by a thenar flap or a palmar flap. Two other methods, however, have to be considered on occasion. These are: (1) resuture of the severed part and (2) proximal reamputation.

Resuture of the severed part is only practicable when less than half of the distal phalanx is involved. It is not often successful. The Gillies method of skinning an amputated digit, burying it in the flank, and then attaching it and the overlying skin as a tube pedicle to the stump of the finger can give a very satisfactory result, but the number of operations makes this procedure justifiable only for selected cases. We use proximal reamputation when extensive proximal injuries make it clear that the digit has no useful future. We then do not suture the tendons across the bone end, as this limits later mobility.

A thin split-thickness skin graft can be expected to "take" uniformly and to be stable on most traumatic amputation stumps of the fingers. It is, however, poorly sensitized, yellow, and unsightly; it does not restore normal convexity to the pulp. We limit its use to elderly patients and to the medial three digits. When there is bone exposed in the stump, we remove the anterior portion of the bone to allow the soft pulp to fall back into contact with the nail bed (after the removal of about four millimeters of the nail).

Our experience with thenar and palmar flaps has convinced us that these flaps, which give a repair by "like" tissue, are the best primary methods for most injuries. They can be done safely under local analgesia on out-patients. The repair of the secondary defect must be meticulously done; it is best done by a dissected full-thickness skin graft cut to the pattern of the defect. This donor site then causes no trouble. We do not see stiffness in these fingers, but we might if we used it more often for elderly patients. The

sensitivity in these stumps, repaired by thenar or palmar flaps with their close-knit subcutaneous texture, is better than that which we see in our free graft repairs or in repairs by flaps from elsewhere in the body. The patients often claim to have normal sensation in these pulps within a week of division of the base of the pedicle. This is of course a matter of interpretation at the cerebral level of deep sensory impulses from the stump. However, the more normal the physiology of the repair—and a repair by "like" tissue gives the most normal physiological restoration to the finger stump—the more the patient is likely to interpret the sensory inflow as normal.

CONCLUSIONS

The most practicable and certain primary method for general use in the repair of traumatic amputation of digits is a cover by a thin split-thickness skin graft, when necessary after anterior shortening of the exposed phalanx. This free graft repair is relatively unsightly and poorly sensitized; but it is much more reliable and its performance needs less experience than a full-thickness skin-graft cover.

The best repair for these common important finger-tip injuries is one by "like" tissue,—that is, by a thenar or palmar flap. When properly executed, these flaps show no disability in the donor sites, give the best-looking stumps and the best return of sensation to them.

DISCUSSION

Dr. Michael L. Mason, Chicago, Illinois: I think Mr. Clarkson's real contribution, apart from his surgery, is his teaching young students, interns, and residents the art of handling tissues. If they can learn to handle small wounds well, they can learn to handle the large ones. The distinction between large and small wounds is not too important, but the handling of the small wound is extremely important. I presume the total amount of disability and the total amount of compensation of all kinds today is very great from small wounds which have been poorly cared for. I am sure anyone who has gone through Mr. Clarkson's training at Guy's Hospital has had a thorough training in the careful handling, careful cleansing, and primary closure of wounds. I do not believe there is any hospital in this country that has a comparable number of injuries to treat as does Guy's in London. I doubt that we here at the Cook County Hospital even have such a volume of patients so well supervised and brought under such care as in Mr. Clarkson's department at Guy's.

I was a little surprised at the low percentage of crushing injuries. It seems to me that we see a larger proportion of crushing injuries; we do not see such a large percentage of lacerations.

I have been rather hesitant about using digital-nerve block, possibly because of prejudice. We used to see necrosis from the use of digital-nerve block. We like to repair small wounds with the blood-pressure cuff applied to the arm instead of using a catheter about the finger for a tourniquet and to carry out infiltration anaesthesia at the site of injury. I have hesitated to use flaps from the palm of the hand to cover the tip of the finger, because I dislike to add a scar to the palm and I fear a flexion contracture in the digit. I must confess that the results Mr. Clarkson has shown certainly tend to discount that prejudice. When I put on a flap, I usually place the finger tip under a flap beneath the breast or on the abdominal wall. Cross-finger flaps are used occasionally and have proved to be valuable.

Dr. J. Edward Flynn, Boston, Massachusetts: The differentiation of the various types of compound wounds of the hand and the treatment of each type have been clearly stressed by Mr. Clarkson. We classify compound wounds of the hand as incised, avulsed, crushed, late, or septic. The incised, avulsed, and crushed wounds may be further classified into clean and dirty. Incised nerves are sutured primarily in all types of wounds except those which are septic. Crushed and avulsed nerves are treated by early delayed reconstruction, usually about six weeks after injury. Fractures are reduced by manipulation in all types of wounds except those which are septic. In septic wounds, fractures are reduced by gradual traction. Extensively crushed and avulsed tendons are never repaired primarily. Incised tendons, usually, may be reconstructed primarily, if too many hours have not transpired since injury.

There have been 612 cases of compound injuries of the hand treated at the Boston City Hospital over the past five years. These cases include tendon and nerve injuries and exclude uncomplicated compound fractures. There were nine cases of sepsis in this series. There were three cases of major sepsis and six cases of minor sepsis. The incidence of sepsis was 1.47 per cent.

We have used pedicle grafts from the thenar area to cover partial amputations of the distal phalanges of the index, middle, and ring fingers, with bone exposed, and from the hypothenar eminence for partial

amputations of the little finger. The tip of the thumb may be covered by a pedicle graft from the dorsum of the middle phalanx of the index finger. Pedicle grafts from the thenar area present a controversial problem. Objections to the thenar pedicle have been a tender scar on the donor site, a hypertrophied scar on the donor site, and stiff fingers. We have not met these complications when the graft has been properly placed on the thenar area, when a full-thickness skin graft is placed on the donor defect, and when the pedicle is detached in twelve days. We have been favorably impressed by our results. The incidence of neuroma formation is small. The stumps are not tender and sensation returns to the pedicle graft.

When one refuses to use a pedicle graft on an amputated finger tip, there are two alternatives,—a split-thickness skin graft for the finger tip or trimming and closure of the stump. When either of the alternatives is selected, the digital nerves on each side of the finger should be crushed, ligated, and transplanted beneath the dorsal skin, away from the wounds. Otherwise a neuroma will develop.

Much has been written in the past ten years about the local use of penicillin for acute suppurative tenosynovitis and deep fascial space infections. Penicillin paste has been packed in wounds. Others have irrigated the tendon sheath with penicillin through a fine rubber catheter, through needles, or ureteral catheters in the sheaths. Others suggest the drainage of thin pus through two transverse incisions, irrigation of the sheath with penicillin, and suturing of the wounds. Mr. Clarkson, have you had any experience with the local use of penicillin for acute suppurative tenosynovitis and deep fascial space infections?

MR. CLARKSON: I cannot give an authoritative answer to Dr. Flynn because I see no more than two deep palmar abscesses a year. We evacuate the pus by incision. Obviously antibiotics play a large part in the success of treatment.

DR. SUMNER KOCH, CHICAGO, ILLINOIS: I realize I am treading on somewhat dangerous ground in speaking critically of Mr. Clarkson's presentation and especially so since he is our honored guest. I am, however, troubled by some of the things that have been presented. I wonder if in this country we are so far behind that we cannot achieve the results that Mr. Clarkson and his associates are getting.

Very few of his patients are admitted to the hospital. In only a very limited number does infection develop. Mr. Clarkson spoke of healing taking place in from seven to ten days after drainage of an infected wound. Rarely, I fear, can we secure such good results. As I recall, there were 3,000 injuries of the hand cared for in Guy's Hospital during 1953. If one omits Sundays, there would be an average of nearly ten a day. I wonder who is taking care of this large group of patients and how a staff caring for such a large number of patients, almost all as ambulatory patients and not under close supervision in the hospital, can secure such excellent results with almost no wound infections. The number of infections was trivial. Such results we have not been able to accomplish. At our own Hospital, we have something close to what we consider an ideal set-up. It is a private hospital where all the men are well trained in this particular field of work. The hand injuries are taken care of by Dr. Mason, Dr. Bell, Dr. Allen, and sometimes by me. At times the resident takes care of the simpler injuries, but most of the patients are cared for by one of the older men. I have followed patients who were taken care of by men who have been with us as long as a year, I recall one such patient seen recently, with amputation of one-third of the distal phalanx of the thumb. A graft was applied with the greatest of care, and I saw the patient from time to time afterward. Although compression and immobilization were carefully maintained and there was minimal wound secretion, complete healing required a month's time. I am simply interested to know where we are falling down and why we cannot secure as good results as have been reported to us.

I would like to know also how often and by what method antibiotic therapy was given when practically all the patients were ambulatory and were not kept in the hospital after their initial care.

MR. CLARKSON: I am grateful to Dr. Koch for giving me further opportunity to clarify something which I tried to make clear in my paper, but which I have apparently not done successfully. It is this. The vast majority of the open hand injuries which I have reported here have been small injuries. A great number would have healed without complication by conservative treatment with a simple dressing, without surgery. However, the whole point of our organization has been to teach that every breach of the full thickness of the skin of the hand should be given full formal treatment in an operating theater. I emphasize again that these are unscreened patients attending without payment and using the hospital as a sort of general practitioner. They represent the total for seven days a week, twenty-four hours a day, the whole year round. The daily number may vary between five and fifteen.

Concerning the incidence of infection following the primary repair, may I explain that I call a major infection one in which the patient goes home after repair but comes back in the next day or two with pain, fever, and gross infection in the wound which necessitates immediate removal of the sutures and drainage. We expect about one in a hundred to behave like this; but last year there were none. Minor infections are those showing pus on the dressings or around the sutures, and a delay in healing. These can be very serious in terms of economic disability and in the quality of the eventual scar. I draw Dr. Koch's attention to the

(Continued on page 548)

THE ROLE OF THE ORBICULAR LIGAMENT IN TENNIS ELBOW *

BY DAVID M. BOSWORTH, M.D., NEW YORK, N. Y.

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"Tennis elbow" is a term which, perhaps, in the past has been used to embrace a variable number of lesions. Tendinitis of the common aponeurotic origin of the extensor muscles of the forearm, bursitis about the tendon and the lateral collateral ligament, epicondylitis or periostitis at the attachment of the common origin of the extensors to the external epicondyle of the humerus, and pinching of the synovial fringe extending into the joint between the capitellum and the radial head, all have been considered as etiological factors causing the pain complained of in the lateral aspect of the elbow.

Treatment has, in the past, promoted recovery in some cases. A goodly number of patients, however, have continued to have complaints of the original pain, despite all forms of treatment, both conservative and operative. We would suggest one further factor which might be a cause of the pain and an operative procedure which has been performed to give relief.

It should be emphasized that tennis elbow is a lesion commonly seen and usually amenable to conservative treatment. Actually, more or less discomfort and tenderness about the common origin of the extensor muscles, the lateral epicondyle, and the radial head are of frequent occurrence in the average population beyond middle age. Aggravation of discomfort when the muscles attached to the lateral epicondyle are placed under tension is common. Usually the condition does not even require the attention of a physician. Many people presenting themselves for examination for other conditions, if the elbow is palpated, will respond with complaints of pain in this area. Frequently such complaints are so slight as to be disregarded. If and when patients appear with the specific purpose of obtaining relief from such symptoms, simple measures, such as heat and massage, occasional splinting for two or three weeks, change in occupation so that the strenuous motion of dorsiflexion of the hand or fingers may be avoided, and occasionally injection of the area with novocain or compound F will, as a rule, stop the pain. In such patients the tenderness and pain tend to wax and wane and never to become disabling. There are, however, a few who must continue strenuous activities previously performed with the hands and wrists in order to earn their living. There are others in whom, following specific strain or trauma, painful lesions develop, which cannot be disregarded. Some of these cannot be relieved until surgery is resorted to.

Innumerable patients with this complaint have been seen in the past fifteen years and from this period the following operative cases were selected. Many patients seen during this period have needed no specific treatment and others have responded well to corrective measures without operation. Twenty-seven, however, have been operated upon by one procedure or another and these form the basis of this report. Eventually, through experience with them, a new procedure was developed, in the hope of improving results.

STATISTICS

Twenty-seven elbows were operated upon for this condition. The ages of the patients ranged from thirty-one to fifty-five years. Only one older patient was encountered, aged sixty-nine years. In twenty of the twenty-seven patients the right elbow was involved and in only seven the left elbow. Duration of symptoms before operation was from two

* Presented before the Orthopaedic Section of the New York Academy of Medicine, New York, N. Y., May 1954.

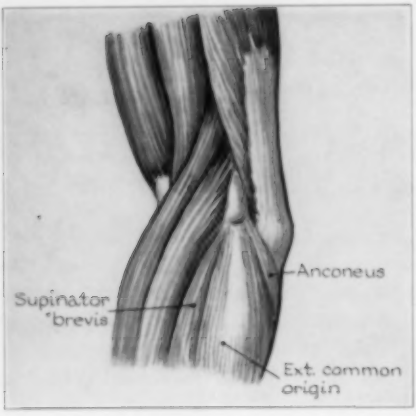

FIG. 1-A

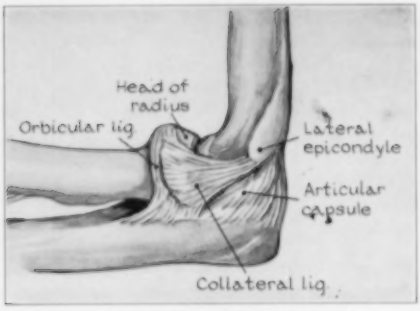

FIG. 1-B

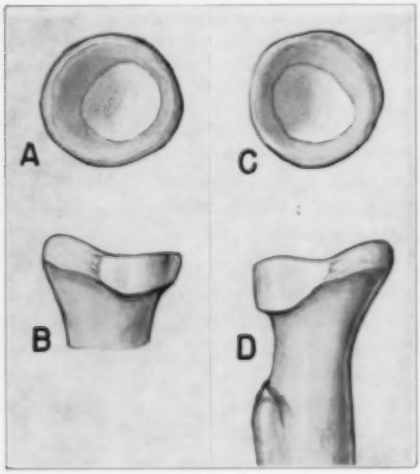

FIG. 1-C

FIG. 1-D

weeks to thirty-six months. In the last four years no patient has been operated upon who had not had symptoms for at least six months. The preoperative treatment had consisted in baking, massage, injections of novocain, splinting (often prolonged), change of occupation, and avoidance of strenuous use of the hand, wrist, and forearm. Fifteen of the patients were compensation cases. The results in these patients equaled those in the rest of the group. Duration of disability postoperatively extended from eight days to six weeks except in two cases, one a compensation case and one not; in these two patients, disability lasted three and four months, respectively. All of the patients have returned to their original occupation, although with variable complaints and findings.

The follow-up period extended from ten months to eleven years. The longer follow-up examinations were of patients returning for conditions other than the elbow. The types of injury were recorded as follows: Fifteen had a blow on the lateral side of the elbow, six had a twisting strain, one stated that the condition resulted from over-use of the hand and forearm, and in five patients there was no known cause. Diagnosis ranged from simple tennis elbow to epicondylitis, tendinitis, and bursitis. The variability of diagnosis seemed to reflect the uncertainty as to the pathological situation causing the symptom complex. A simple diagnosis of tennis elbow has been employed recently. In view of the

short follow-up period and the limited number of cases, this must be considered a preliminary report.

The occupations recorded practically cover the employable personnel in our metropolis. Dentist, nurse, carpenter, bricklayer, presser, and bookkeeper, all are listed. Only two occupations appear more than once on the list,—three nurses were operated upon for this condition and two dentists. Two patients had the second elbow operated upon after a long interval.

ANATOMY

The anatomy of the muscles on the lateral side of the elbow is shown in Figure 1-A. The radial nerve lies three centimeters anterior to the incision and may be, but usually is not, visualized.

The anatomy of the ligamentous structures on the lateral side of the elbow appears in Figure 1-B. It will be noted that the radial collateral ligament in its distal portion sweeps forward and its fibers merge with the orbicular ligament. Some of its fibers extend back to the ulna distally. The deep surfaces of the overlying muscles are intimately attached to the ligaments beneath. The collateral ligament, orbicular ligament, and capsule fibers merge with one another.

Osteology of the radial head (Fig. 1-C) shows the following:

First, it is not quite circular as seen from above;

Second, it is not concentric with the radial shaft but is slightly offset;

Third, one margin is considerably elevated above the opposite margin;

Fourth, its peripheral border varies considerably in width;

Fifth, its lateral border is not smoothly molded throughout its circumference, but shows considerable irregularities.

Roentgenograms (Fig. 1-D) of the same specimens represented in Figure 1-C, and in the same relative positions, show radial heads from right and left elbows, in a position of partial supination. They confirm these findings.

We believe that rotation of this distorted head in a changing plane, on a changing stress axis, inside a sensitive membrane, compressed by powerful muscles and tendinous structures would be capable of producing the pain of the tennis elbow.

TYPES OF OPERATION EMPLOYED

Four distinct operative procedures have been used for these patients.

First Type of Operation

This procedure consisted in complete division of the common aponeurotic origin of the extensor muscles. Thirteen operations of this type were performed. While all of these patients returned to their previous occupation, most of them still experienced an appreciable amount of tenderness and some soreness during the follow-up period. One patient, eleven years afterwards, stated that "the elbow was still slightly sore". Another "had pain on heavy lifting". Almost universally the elbow was still symptomatic enough, so that it was noticeable and annoying to the patient, although all admitted that they were greatly improved.

Second Type of Operation

This operation consisted in complete division of the common origin of the extensor muscles and removal of the synovial fringe between the capitellum and the head of the radius. Four patients were operated upon by this method. All four had mild residual pain when last seen. This was increased by overuse and was associated with moderate tenderness or muscle cramping. All were markedly improved over their preoperative condition, but were still slightly annoyed by the pain.

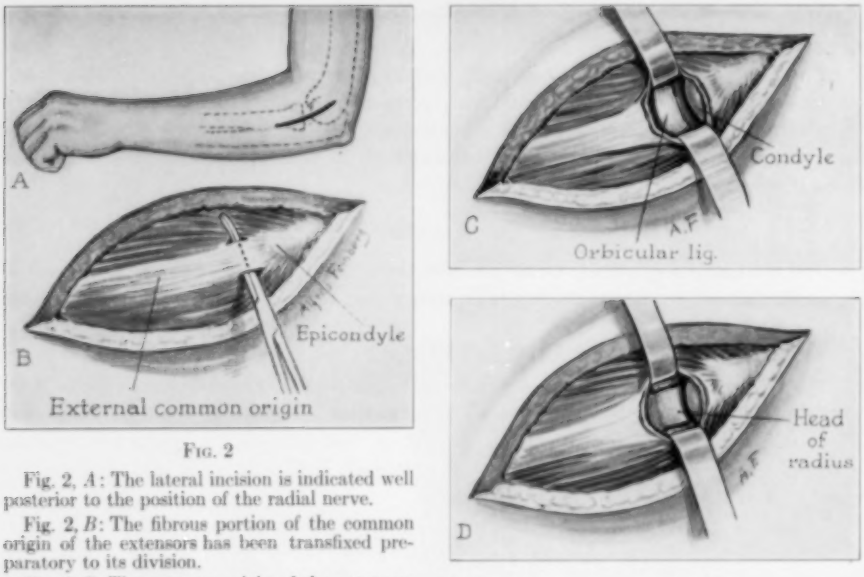

FIG. 2

Fig. 2, *A*: The lateral incision is indicated well posterior to the position of the radial nerve.

Fig. 2, *B*: The fibrous portion of the common origin of the extensors has been transfixed preparatory to its division.

Fig. 2, *C*: The common origin of the extensors has been divided and the orbicular ligament has been exposed. The collateral ligament has been retracted below and part of its anterior margin has been removed in order that the orbicular ligament may be visualized. Only the posterior portion of the collateral ligament need be retained.

Fig. 2, *D*: Resection of as much of the orbicular ligament as can be reached with ease anterior to the collateral ligament is done.

Third Type of Operation (Figure 2, *A*, *B*, *C*, and *D*)

This procedure consisted in complete division of the common origin of the extensors and resection of the orbicular ligament from around the head of the radius. This was first done in October 1943 and occurred through chance resection of a part of the orbicular ligament while a section of the common origin of the extensors was being removed for microscopic study. Excellent and prompt recovery from symptoms occurred. We did not at that time attach any importance to the specific removal of the orbicular ligament in the treatment of the tennis elbow. Because of the section of the orbicular ligament, the patient was held under observation for eight months. We were fearful of displacement of the radial head. No relaxation of the lateral ligament of the elbow joint or displacement of the radial head was found to occur, nor could any be produced by manipulation. The discussion arising, of course, did draw our attention to the orbicular ligament.

A physician appearing soon after the discharge of the above patient had complete resection of the common origin of the extensors in June 1945. Special attention was paid to preserving the orbicular ligament. During the operation, however, it was noted that the orbicular ligament, released from its attachment to the lateral epicondyle of the humerus, slipped down over the neck of the radius. Prompt and complete relief was obtained and no recurrence has taken place to date, nine years later. However, in this same doctor, a similar condition developed on the opposite side in 1952. She was so pleased with the result of the previous operation that she demanded that a similar procedure be used on this second elbow. Noting our report of the previous operation, we purposely divided all attachments of the orbicular ligament to the humerus and allowed it to slip down over the head of the radius. Again rapid and complete relief of symptoms resulted.

One would have thought that by this time we would have recognized the efficacy of either displacing the orbicular ligament from the head of the radius or of dividing it. We had had three clear-cut indications that this procedure reduces the chances of further

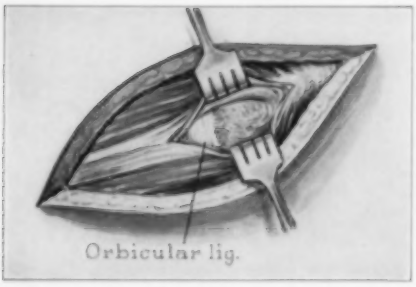

FIG. 3-A

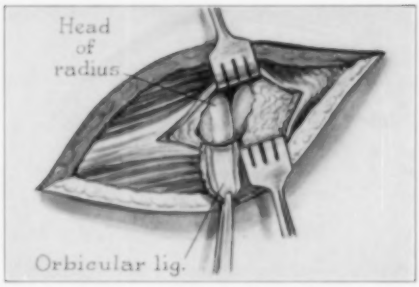

FIG. 3-B

Fig. 3-A: The common origin of the extensors has been split longitudinally in line with its fibers and the anterior fibers of the collateral ligament have been removed, exposing the orbicular ligament.

Fig. 3-B: The orbicular ligament has been divided anteriorly and drawn backward prior to division just under the anterior margins of the collateral ligament. The common origin of the extensors will be sutured and retained.

complaints. However, not until November 1952, when a patient appeared who had had both elbows operated upon without relief, one of them twice, did we specifically plan to excise the orbicular ligament. This type of procedure, which included division of the common origin of the extensors and resection of the middle three fifths of the orbicular ligament, was performed on the left elbow and relieved the patient completely. He still could not return to his previous occupation, which demanded a twisting motion with his hands and forearms, because of the painful opposite elbow. Eight months later, he requested that the second elbow be operated upon in a similar fashion. Again this third type of operation was performed. The patient has completely recovered.

After having done Type 3 operation with division of the common origin of the extensors and resection of the orbicular ligament in three instances and displacing it down around the neck of the radius in two, we felt that the next logical step was merely to resect the orbicular ligament and to leave the common origin intact.

Fourth Type of Operation (Figures 3-A and 3-B)

This operation has been used in an experimental group of four patients in whom the common origin of the extensors has been split vertically, a segment (approximately half) of the orbicular ligament has been resected and the common origin of the extensors has then been resutured with chromic catgut over the head of the radius. Since Type 3 operation including transection of the common origin had resulted in but little clinical defect as to power of extension of the wrist or fingers and has given excellent relief of symptoms, we approached this last, experimental procedure with considerable apprehension. This was to be the proof of the role played by the orbicular ligament in the production of symptoms causing tennis elbow.

There has been a follow-up period of only ten to fourteen months in these patients. Therefore, for these patients this report must be considered preliminary. All four of the patients have markedly improved. Three are completely asymptomatic. The most recent patient still has minimal tenderness over the incisional area. It does not seem to us that recovery was much more prompt or the final status any better than when the Type 3 operation was done with division of the common origin and of the orbicular ligament. However, in these patients the results from removal of the orbicular ligament have more than equaled the results from previous operations of (1) simple division of the common origin of the extensors or (2) the operation in which the common origin was divided and the synovial fringe was removed. For the present and until a few more experimental cases of simple removal of the orbicular ligament have been done and a longer follow-up period has been allowed to elapse, it is probably wise to carry out the procedure referred

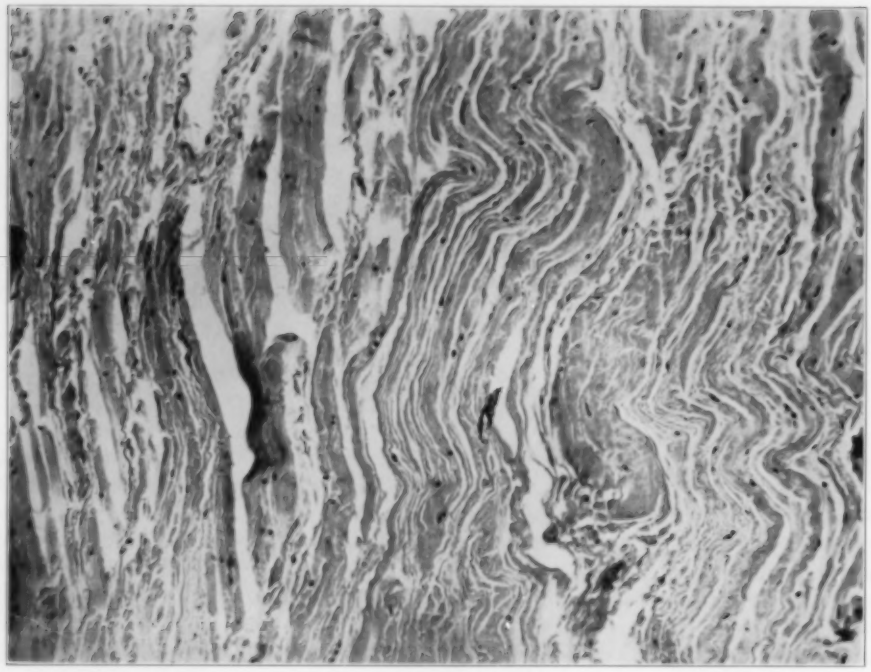

FIG. 4-A

Fibrous tissue from the region of the orbicular ligament, showing evidence of hyaline degeneration.

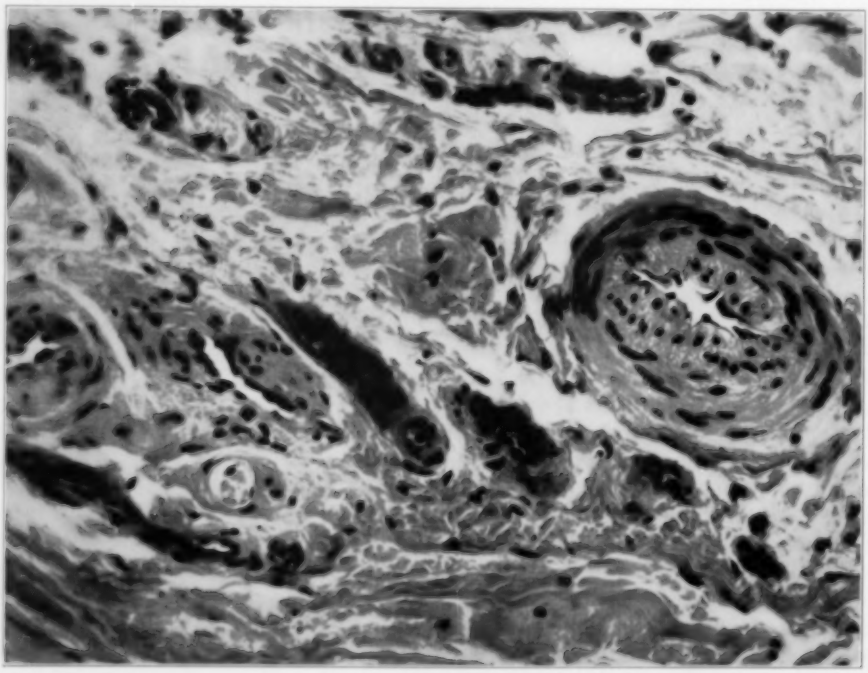

FIG. 4-B

Tissue from the region of the orbicular ligament, showing marked thickening of blood vessels.

to as Type 3 with division of the common origin of the extensors and removal of the orbicular ligament. Certainly, in cases previously operated upon without relief, when the orbicular ligament has not been touched, a complete removal of scar tissue, as well as of the orbicular ligament, seems indicated.

Photomicroscopy

Photomicrographs of orbicular ligaments removed show hyaline degeneration, disorganization of structure, and reduction in number of nuclei in fresh cases (Fig. 4-A), and sometimes obliterative endarteritic changes in the vessel walls in patients previously operated upon (Fig. 4-B).

FIG. 5

Resection of the common origin of the extensors improved motion and stopped pain in this patient with a malunited fracture of the radial head.

MALUNION FRACTURE OF THE RADIAL HEAD

One other patient had had a fractured head of the radius (Fig. 5) which had healed with irregularity of the radial head. There was limitation of elbow motion and forearm rotation with continuous pain. After resection of the orbicular ligament, she was completely relieved of symptoms and obtained normal motion. The procedure used was based upon our experience with the patients with tennis elbow.

COMMENT

We believe that we have demonstrated that the orbicular ligament is a considerable factor in the production of the pain experienced in tennis elbow. Resection of the orbicular ligament or its displacement downward around the neck of the radius, accompanied by division of the common origin of the extensor muscles, has given complete relief in five cases. Experimental removal of the orbicular ligament alone with resuture of the common origin has given complete relief of symptoms in three cases and in another case relief equal to that afforded by simple division of the common origin alone with removal of the fringe between the head of the radius and the capitellum. Recovery from soreness of the incisional area has been less rapid when resuture of the common origin has been done. Removal of a section of the orbicular ligament in a patient with malunited fracture of the head of the radius has given relief of pain and has resulted in markedly increased joint motion. No instability of the head of the radius on the ulna can be demonstrated by manipulation in these patients. For the present, it is probably better to divide the common origin of the extensors completely and to remove the orbicular ligament, leaving the head of the radius covered merely by adipose tissue and skin integument.

It may be that resection of the orbicular ligament alone may be found sufficient to alleviate the symptoms of tennis elbow. If so, we could then theoretically conserve strength of dorsiflexion of the wrist and extension of the fingers, as well as lateral stability of the elbow, by no longer dividing the common origin of the extensors. We believe this probably to be so. Further time will have to pass before a final opinion can be rendered as to the permanency of relief from orbicular-ligament resection alone, either in tennis elbow or in malunited fracture of the head of the radius.

A TRANSVERSE ANTERIOR APPROACH TO THE HIP *

BY J. VERNON LUCK, M.D., LOS ANGELES, CALIFORNIA

The transverse anterior approach to the hip here described was originally developed to carry out more easily the writer's transverse intertrochanteric reconstruction of the hip for ununited fractures of the neck of the femur associated with absorption of the neck and a healthy femoral head [2,3,4]. However, the approach has proved helpful in carrying out a wide range of operative procedures, such as arthroplasty of the hip, open reduction of fracture of the hip, pinning or grafting of fracture of the neck of the femur, replacement and fixation of slipped capital femoral epiphysis, and the insertion of an upper femoral prosthesis. It is not the best approach for open reduction of congenital dislocation of the hip or other instances in which the femoral head or acetabulum are widely displaced proximally. Hueter's approach, recommended by the Judet brothers, serves well for the insertion of the Judet prosthesis, but it is generally inadequate for the insertion of a medullary-stem prosthesis. The transverse anterior approach gives the view of the hip joint offered by the Hueter approach and, at the same time, gives the needed exposure of the trochanteric region.

A review of the medical literature of this century disclosed no description of a transverse anterior approach to the hip. In the last century, there were some references to transverse approaches but none which were found were the same as the versatile approach here described.

ORIENTATION

The landmarks for this transverse approach are the anterior superior iliac spine, the greater trochanter, and the symphysis pubis. In order to locate the femoral head, the usual surface line is projected between the anterior superior iliac spine and the symphysis pubis; the femoral head is below the mid-point in that line. The greater trochanter is subcutaneous, even though the fascia lata and the walls of the trochanteric bursa lie between it and the skin. Both the intertrochanteric area and much of the hip-joint capsule are covered by the tensor fasciae latae.

TECHNIQUE

After the patient has been placed on the operating table in the supine position, a medium-sized sandbag is thrust well under the buttock on the side of the operation. The medial end of the transverse skin incision should lie over the femoral head. It is begun just lateral to the mid-point between the anterior superior iliac spine and the symphysis pubis. The incision is directed lateralward in the skin lines in or near a flexor crease of the hip and is ended at a point lateral to the femur in the region of the greater trochanter. If the hip is placed in slight abduction and slight flexion, the intertrochanteric area will lie beneath the incision. Prior to the transverse sectioning of the tensor fasciae latae, when required, the subcutaneous fat and skin are dissected from the fascia lata and the tensor muscle for 2.5 or 5 centimeters above and below the level of the skin incision. Care must be taken to identify clearly the tensor fasciae latae before it is sectioned. This can be done by sectioning the fascia lata laterally over or distal to the trochanteric area. After this has been done, all aspects of the muscle are readily visualized. In some cases, the lateral end of the skin incision may need to be advanced two to five centimeters distally in order to reach and to section more easily the distal third of the tensor fasciae latae. The nerve of the tensor fasciae latae enters the muscle posteriorly in its proximal half and is not disturbed since the transverse sectioning of the muscle is carried out in the distal third of the muscle.

* Read at the Annual Meeting of the Western Orthopedic Association, San Francisco, California, October 16, 1954.

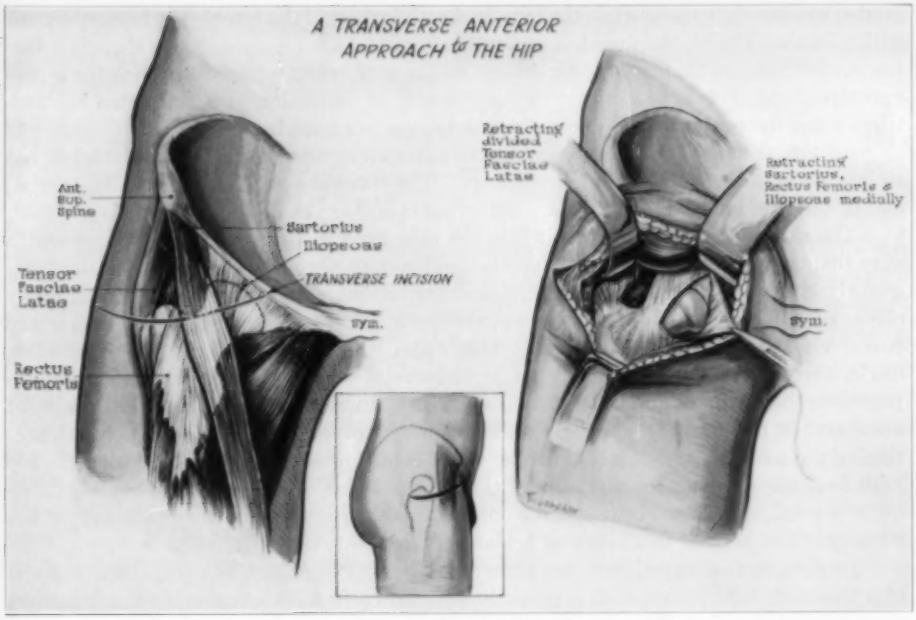

FIG. 1

After the sectioned fascia lata and the tensor fasciae latae have been retracted proximally and distally, the sartorius, the rectus femoris, and the iliopsoas are retracted medially. The capsular attachments of the rectus femoris are dissected from the capsule in order to facilitate the medial retraction. Whether or not the origin of the rectus femoris from the anterior inferior iliac spine is sectioned depends upon the extent to which exposure of the acetabulum is required by the operation. When the tensor fasciae latae has been completely retracted from the operative field, it may be unnecessary to section the rectus femoris for an adequate view of the acetabulum.

Laterally, the approach may include, if desired, detachment of the glutaeus medius and glutaeus minimus, with or without detachment of the greater trochanter. Actually, a medullary-stem prosthesis can generally be nicely inserted without the removal of the abductors or of the greater trochanter. If there is need for transplantation of the greater trochanter distally, this can be carried out with ease. In more difficult insertions of medullary-stem prostheses, the lateral end of the skin incision can be curved proximally for five centimeters or more. The incision in the fascia lata can also be extended upward between the posterior margin of the tensor fasciae latae and the anterior margin of the glutaeus maximus. When this proximal extension is employed, it is frequently unnecessary to divide the tensor fasciae latae transversely.

If, in addition to the hip exposure, an exposure of the upper quarter or third of the femoral shaft is needed, the lateral end of the transverse incision in the skin and the fascia lata can be curved distally and can be carried as far as needed down the lateral aspect of the upper portion of the thigh.

When only the hip joint proper is to be opened and explored, the transverse incision in the skin need not be carried so far laterally, and the tensor fasciae latae need not be sectioned. Such an incision is indicated in biopsy of the hip and the evacuation of exudates. The tensor fasciae latae may be retracted and need not be sectioned, even in extensive operative procedures, if the tissues are relaxed and lend themselves to wide retraction.

Closure of the operative wound is facilitated by moderate flexion of the hip. Interrupted sutures are used in closing the fascia lata and muscle sheath. Mattress sutures are

needed to close the muscle when the muscle sheath is thin. If the muscle has been sectioned within its distal third, the sheath is well formed and is easily repaired. When there is a flexion contracture of the hip, the structures in need of being released are directly in the operative field. This is in contrast to the difficulty in correcting such associated contractures when the posterior and posterolateral approaches have been used.

As with the use of the Hueter and Smith-Petersen approaches, care must be taken not to injure the lateral femoral cutaneous nerve. The femoral vessels lie beneath the medial end of the skin incision, but they are not exposed and are in no danger of injury.

The skin incision, directed as it is in the skin lines, heals in a splendid manner with very little scarring and does not have the tendency to a spreading scar; such a scar frequently characterizes the incisions of the other anterior approaches which cut directly across the skin lines. Transverse skin approaches are increasingly employed in preference to many of the longitudinal approaches. This is particularly true of approaches to the knee, ankle, shoulder, elbow, wrist, and hand. Abdominal surgeons praise the transverse approach to the abdomen and contend that transverse division of the rectus abdominis is not associated with untoward effects. No ill effects whatever have been identified with sectioning the tensor fasciae latae. With the use of some hip approaches which reach the hip joint between the glutaeus medius and the tensor fasciae latae, the tensor muscle is frequently paralyzed, as has been pointed out by Abbott. The nerve to the tensor muscle lies directly in the path of these approaches and is frequently divided.

In my personal experience, the transverse anterior approach has withstood the test of a thorough trial period and in properly selected cases has clearly evident advantages over other approaches. The approach is direct, versatile, simple, and relatively bloodless.

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DISCUSSION

Dr. LeRoy C. Abbott, San Francisco, California: I have not used the exact approach described by Dr. Luck, but I have used a transverse anterior approach for the rapid exposure and drainage of the hip joint in cases of marked sepsis of the joint, as seen in France during World War I. At that time, Dr. Philip Wilson and I used this method for excision of the head of the femur in order to obtain drainage and also as the first stage for disarticulation of the hip. With the advent of antibiotics the need for these is rare. I would agree with Dr. Luck that the approach he has just presented is an excellent one for exposure of the anterior aspect of the neck of the femur and the greater trochanter. It especially appeals to me for open reduction and nailing of fractures of the neck of the femur because, with division of the lower part of the tensor fasciae latae, complete visualization in continuity of the neck of the femur and the greater trochanter is possible. The head of the bone and the rim of the acetabulum can also be exposed by division of the reflected head of the rectus femoris and the glenoidal labrum.

I do not believe, however, that Dr. Luck's method is adequate for complete exposure of the posterior and inferior aspects of the joint, especially in cases of marked destruction with fixed deformity in flexion and adduction. Here, an approach successfully used by Dr. Floyd Jergesen, which he calls a comprehensive approach to the hip joint, is more suitable. In the preparation of his paper, written with me, on the subject [a], Dr. Jergesen made an extensive review of the literature. Others such as Vidal (1847), Roser (1854), Schillbach (1861), and Schmid (1891) have used approaches similar to that Dr. Luck has described. Dr. Luck has, however, had a valuable experience and has given a careful anatomical description of his incision. His operation is conservative in that no important blood vessels or nerves are divided. We should be grateful to Dr. Luck for this very simple effective method of exposure of the hip joint. The skin incision heals well because it follows the flexion creases of the anterior aspect of the hip. I might add that this incision is particularly suitable for patients living in Southern California because it gives a satisfactory scar which can be covered even with the present-day scanty bathing attire.

[a] Jergesen, Floyd, and Abbott, L. C.: A Comprehensive Exposure of the Hip Joint. J. Bone and Joint Surg. (in press).

ROLE OF THYROID HORMONE IN THE PATHOGENESIS OF JOINT DISEASE IN MICE

Effects of Radiothyroidectomy and High-Fat Diets *

BY MARTIN SILBERBERG, M.D., AND RUTH SILBERBERG, M.D., ST. LOUIS, MISSOURI

From the Snodgras Laboratory, Hospital Division, City of St. Louis, and the Department of Pathology, Washington University, School of Medicine, St. Louis

In aged mice of various strains articular changes develop which may be considered analogous to degenerative joint disease or osteo-arthritis in man. The susceptibility to these lesions varies with the strain used. The onset of the arthropathy may be accelerated and its severity may be increased by feeding the animals a high-fat diet. Again, however, strain differences existed in the response to changes in the dietary regimen: In mice of strain $C_{57}BL$ which were fed a high-fat diet, the incidence of osteo-arthritis was doubled, while in mice of strain Dba the same diet caused only minor articular changes [8]. That these differences might be of a general metabolic character seemed indicated by the fact that the fat-enriched diet increased body weight and shortened the life span of $C_{57}BL$ mice but did not significantly affect Dba mice [6]. Since $C_{57}BL$ mice are hypothyroid as

TABLE I

Distribution of Mice in the Various Experimental Groups *

Strain	Stock Diet: No. of Mice with Intact Thyroids	Stock Diet: No. of Mice Thyroidectomized with I^{131}	High-Fat Diet: No. of Mice with Intact Thyroids	High-Fat Diet: No. of Mice Thyroidectomized with I^{131}	Total No. of Mice
$C_{57}BL$	113	55	159*	47	374
Dba	80	49	63	62	254
All mice:					628

* 111 mice received the high-fat diet from the age of one month on, and 48 from the age of six months on.

compared with Dba mice[1, 8] and since the thyroid plays a role in the metabolism of fats, it was thought that differences in thyroid activity might be one of the causes of these strain differences. Therefore, the effects of a high-fat diet were studied in thyroidectomized mice, and the articular changes found in these mice will presently be described.

MATERIAL AND METHODS

The findings are based on observations of 628 male mice of the closely inbred strains $C_{57}BL$ and Dba raised in our laboratory. One hundred and two $C_{57}BL$ mice and 111 Dba mice were radiothyroidectomized at the age of six months by the injection of a single dose of 400 microcuries of radio-active iodine (I^{131}). Of these animals, fifty-five mice of strain $C_{57}BL$ and forty-nine mice of strain Dba were kept on a stock laboratory diet which contained 5 per cent. fat, while forty-seven mice of strain $C_{57}BL$ and sixty-two of strain Dba were given a fat-enriched diet containing about 30 per cent. fat. This diet, prepared by grinding the regular laboratory rations to a meal and adding 25 per cent. lard, is adequate

* The investigation was supported by Research Grant PHS A22(C3) from the National Institute of Arthritis and Metabolic Diseases of the National Institutes of Health, Public Health Service, and by a Grant from the American Cancer Society on recommendation of the Committee on Growth of the National Research Council.

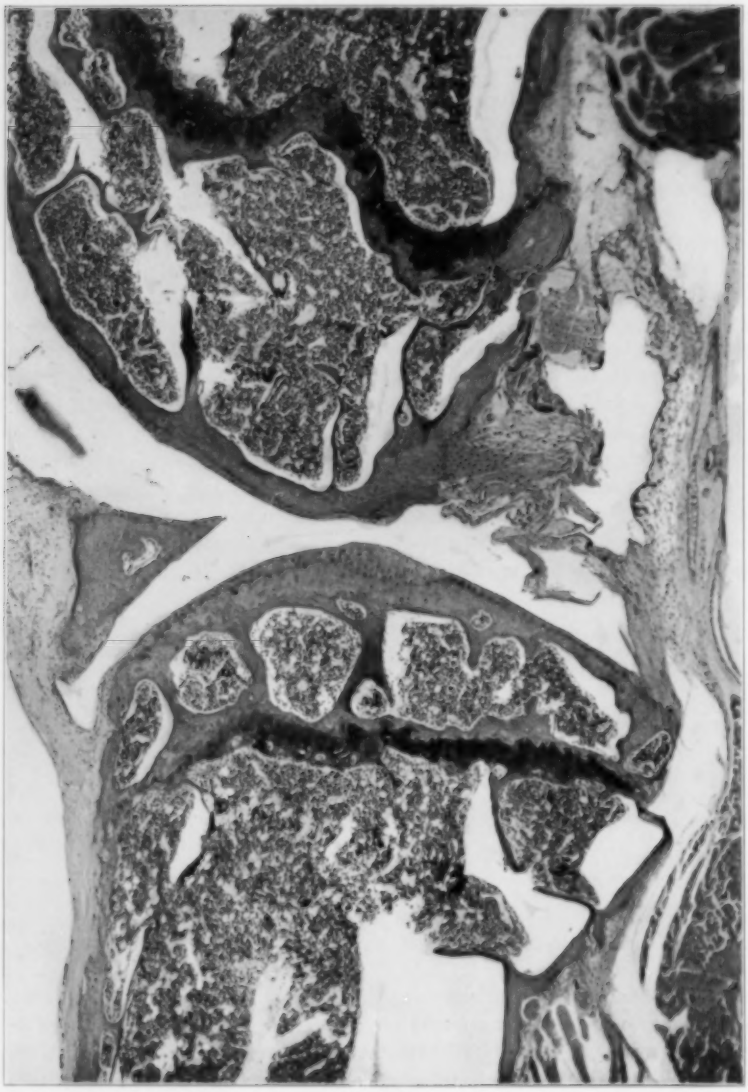


FIG. 1

The photomicrograph (× 40) shows a section through the normal knee joint of an untreated mouse; parts of the joint capsule, the lower end of the femur, the upper end of the tibia, the menisci, and the ligaments can be seen. (Reproduced by permission from "Athyroid Joint Disease in Mice of Various Ages" by Martin Silberberg and Ruth Silberberg, *A.M.A. Archives of Pathology*, 58: 229, 1954.)

in all respects and is well tolerated by the animals; its exact composition has been given previously [8]. Both diets were fed *ad libitum*, and water was available at all times. The weights of the animals were taken at monthly intervals.

With the exception of animals which died or which had to be killed because of hypophyseal tumors developing after injection of I^{131} or because of unrelated diseases, the mice were killed at predetermined ages, usually at twelve, fifteen, eighteen, or twenty-four months. At necropsy, the knee joints were removed and were prepared for microscopic examination, as outlined elsewhere [8]. The results obtained in the "athyroid" mice were

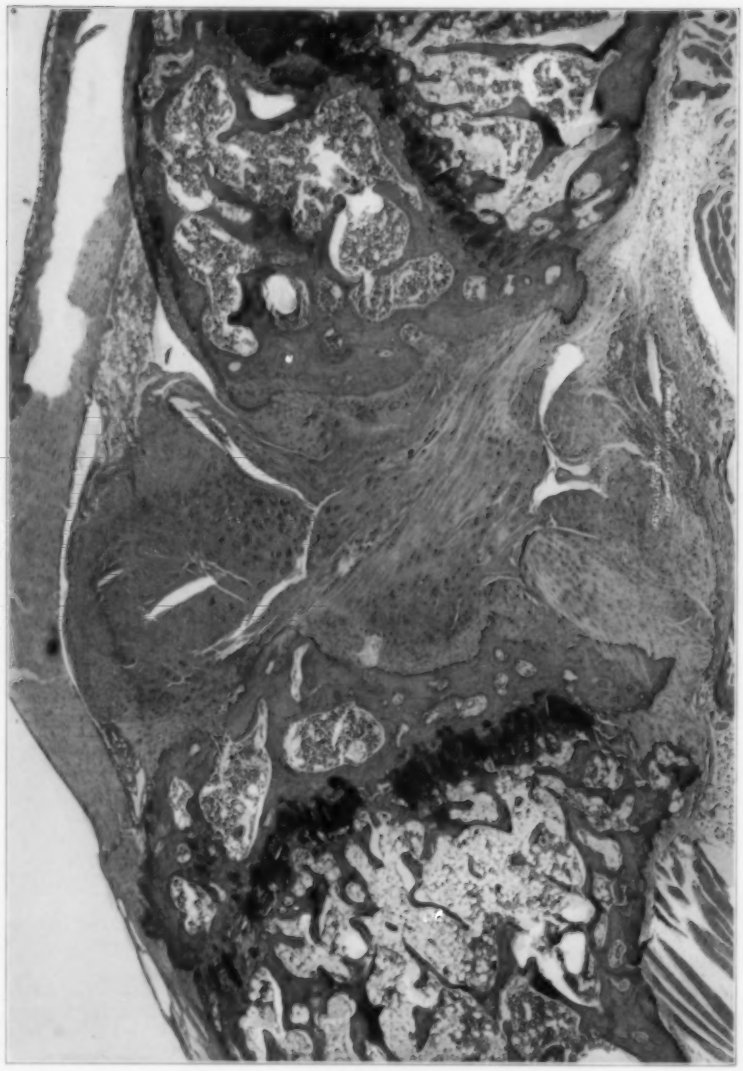


FIG. 2

Photomicrograph (× 40) of section through the knee joint of a fourteen-month-old Dba mouse which had been radiothyroidectomized at the age of one month. The menisci are swollen and vacuolated and consist of bulky fibrocartilaginous material; the ligaments and synovial membrane are likewise swollen, and the joint cavity is obliterated. The epiphysis of the tibia is flattened and distorted.

compared with those established in mice with intact thyroid glands which had been fed the stock diet and the high-fat diet, respectively. Details of the distribution of the animals over the various experimental groups are given in Table I.

OBSERVATIONS

Weights

C_{57}BL mice which had been fed the high-fat diet from the time they had been weaned through life showed higher mean weights than the stock-fed animals: The greatest differ-

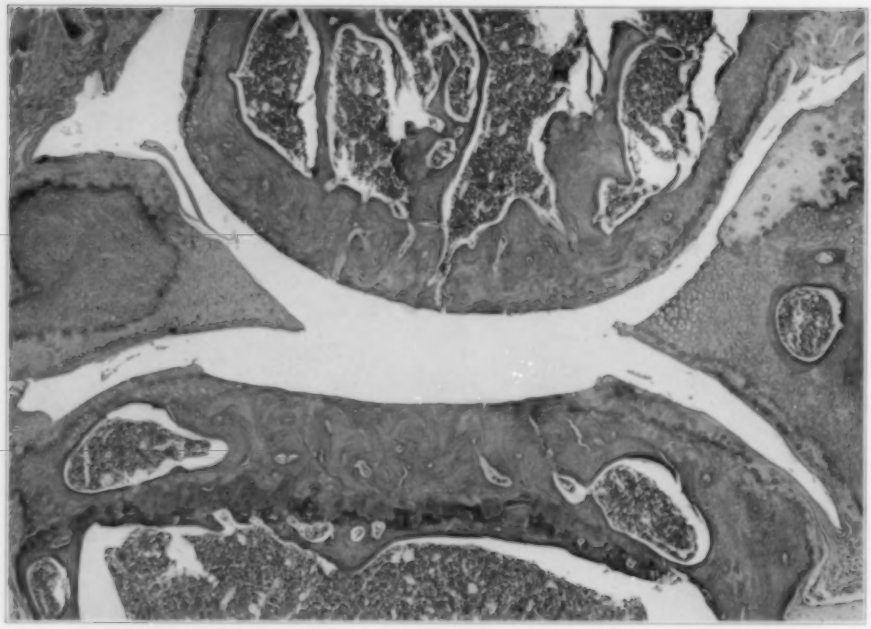


FIG. 3

Photomicrograph (× 52.5) of section through the knee joint of a twenty-four-month-old $C_{57}BL$ male. There is an osteo-arthritic ulcer, with eburnation of the floor of the ulcer. Some proliferation of the cartilage is seen on the surface of the meniscus at the right.

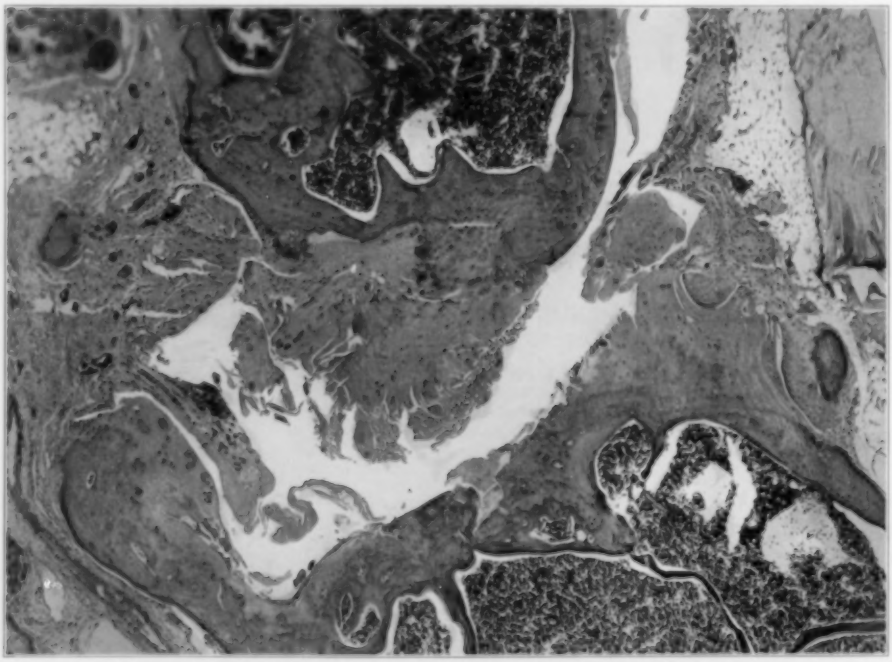


FIG. 4

(See page 541)

Fig. 4: Photomicrograph (× 45) of section through the knee joint of an eighteen-month-old $C_{57}BL$ male. There is osteo-arthritis, with hypertrophy and degeneration of the cartilage and ligaments, as well as fraying and fibrillation. The ulcer at the head of the tibia, with a marginal outgrowth at the left, is seen in the lower part of the photograph.

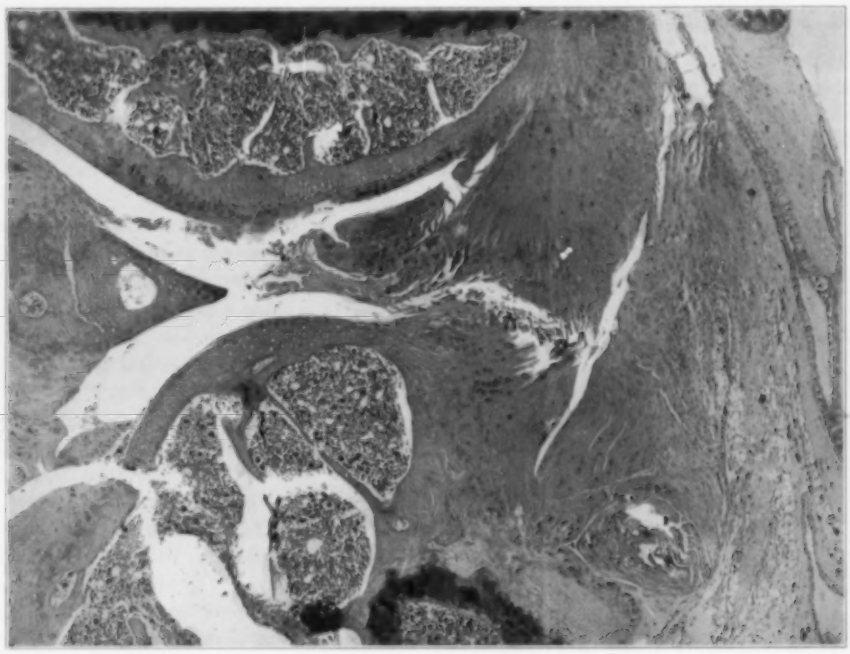


FIG. 5

Photomicrograph (× 32.5) of section through the knee joint of a nineteen-month-old Dba male which had been radiothyroidectomized at the age of six months. There is a mixed type of arthropathy,—athyroid joint disease with osteo-arthritic features. The menisci and ligaments are swollen and degenerated. The meniscus on the right is better preserved than that on the left. The cartilage at the surface of the tibia is hyperplastic and hypertrophic. There is an early ulceration in the center.

ences in the mean weights of the two groups were noted at twenty-two months of age and amounted to 25 per cent.; individual deviations from the mean weights reached +28.9 grams in mice which were fed the high-fat diet, while in the stock-fed mice such variations were slight and did not exceed +8.6 grams. $C_{57}BL$ mice which were fed the fat-enriched diet from the age of six months showed a maximum gain of only 10 per cent. over that of the stock-fed animals. In Dba mice, on the other hand, the differences in the mean weights of the two dietary groups were insignificant. Details of these weight changes have been reported previously [8].

The weights of radiothyroidectomized $C_{57}BL$ mice remained below those of their respective controls with intact thyroid glands. However, athyroid mice of strain $C_{57}BL$ which had been fed the high-fat diet gained 10 to 13 per cent. more weight than did the athyroid controls which had been fed the stock diet. Thyroidectomized Dba mice did not gain weight if they were fed the high-fat diet; there was even a slight tendency for them to lose weight under these conditions.

MICROSCOPIC EXAMINATION

Hypophyseal Tumors

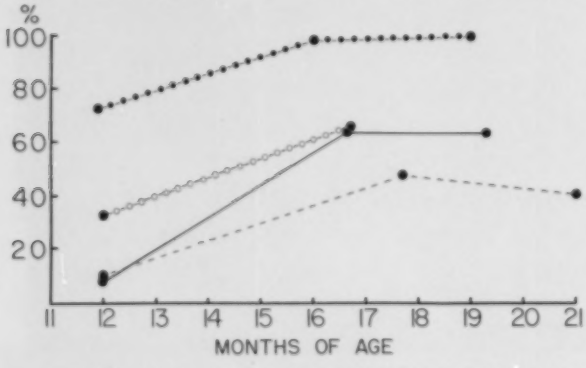
In many mice thyroidectomized with I^{131} hypophyseal tumors developed which produced large amounts of thyrotrophin. As discussed elsewhere [7], it is unlikely that the thyrotrophic hormone plays a major role in the pathogenesis of the articular lesions.

Occasionally small islands of residual or regenerated thyroid tissue may be found in microscopic sections of the neck region. However, these small amounts of thyroid tissue have no functional significance.

Articular Changes

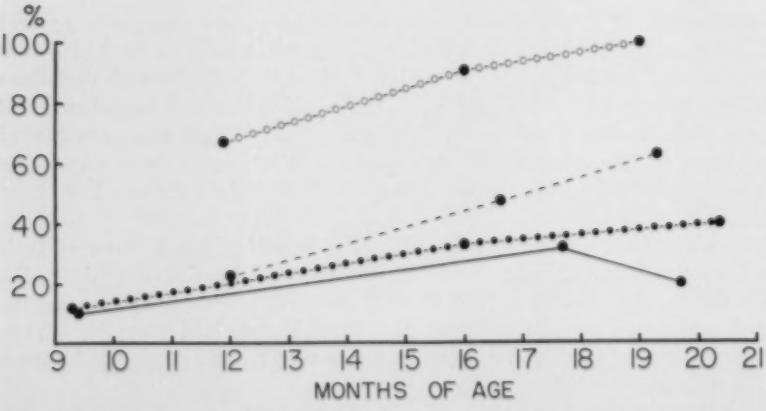
Mice with intact thyroids: The early osteo-arthritic changes which occur in aging mice consist of hyperplasia and hypertrophy of the articular cartilage, followed by or associated with degeneration of matrix and cells. Advanced lesions are characterized by ulcerations of the articular cartilage, with eburnation of the underlying bone, marginal outgrowths of cartilage and bone, ossification of the ligaments, and fibrosis and ingrowth of the synovial membrane into the epiphyseal marrow (Figs. 1 through 3).

Radiothyroidectomized mice: In mice thyroidectomized with I^{131}, articular lesions were found which could easily be distinguished from osteo-arthritis seen in old mice. Athyroid joint disease is characterized by the early involvement of the menisci and the ligaments; the menisci show swelling and vacuolation of the cartilage, with retarded ossification; eventually they break down, and there is mucoid change and hyalinization of the ligaments and synovial membrane leading to the obliteration of the joint cavity (Fig. 4). The articular cartilage is not primarily involved, but, in advanced stages of the joint disease, it may show hypertrophy and hyperplasia of the cells and degeneration of the matrix and the cells. Under



ATHYROID JOINT DISEASE. ●——● Dba MICE, STOCK DIET; ●•••● Dba MICE, HIGH FAT DIET; ●- - - -● C_{57} BL. MICE, STOCK DIET; ●-o-o-● C_{57} BL. MICE, HIGH FAT DIET.

CHART I



OSTEOARTHRITIS AND OSTEOARTHRITIC FEATURES IN MICE OF STRAIN Dba ●——● NON-THYROIDECTOMIZED, STOCK DIET; ●•••● NON-THYROIDECTOMIZED, HIGH FAT DIET; ●- - - -● RADIO-THYROIDECTOMIZED, STOCK DIET; ●-o-o-● RADIO-THYROIDECTOMIZED, HIGH FAT DIET.

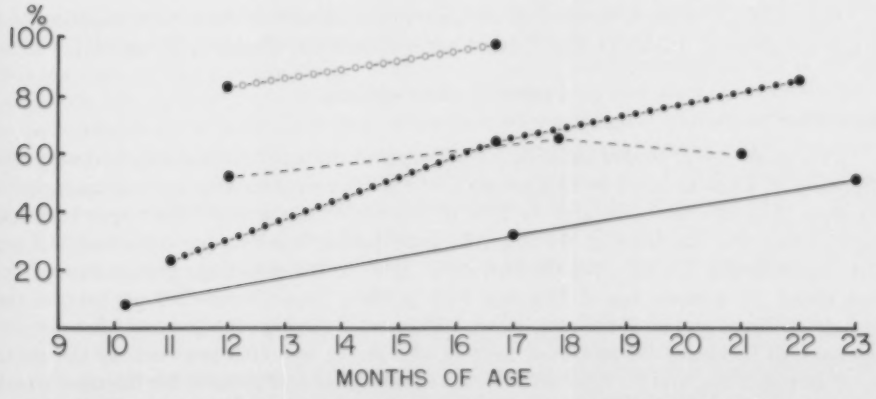
CHART II

TABLE II

FINDINGS IN THE JOINTS OF MICE OF STRAINS DBA AND C_{57}BL RADIOTHYROIDECTOMIZED AT THE AGE OF SIX MONTHS AND FED THE STOCK DIET OR THE HIGH-FAT DIET

Strain	Diet	Age Group (*Months*)	No. of Mice	Mean Age (*Months*)	Athyroid Joint Disease (*Per cent.*)	Mice with Joints Showing Osteo-Arthritic Features (*Per cent.*)
Dba	Stock diet	9 to 12	13	12.0	7.7	23.1
		13 to 18	25	16.6	64.0	48.0
		19+	11	19.3	63.6	72.7
Total		9 to 19+	49	16.0	49.0	47.1
Dba	High-fat diet	9 to 12	15	11.9	73.3	66.7
		13 to 18	42	16.0	97.6	90.5
		19+	5	19.0	100.0	100.0
Total		9 to 19+	62	15.2	91.9	88.5
C_{57}BL	Stock diet	9 to 12	10	12.0	10.0	50.0
		13 to 18	23	17.7	47.9	65.2
		19+	22	21.0	40.9	59.1
Total		9 to 19+	55	17.8	38.2	60.0
C_{57}BL	High-fat diet	9 to 12	12	12.0	33.3	83.3
		13 to 18	35	16.7	65.7	97.1
		19+	0	—	—	—
Total		9 to 19+	47	15.5	57.4	93.6

these circumstances, especially if the mice live to an old age, it may be difficult to decide whether the changes in the cartilage are due to spontaneous osteo-arthritis or to prolonged athyroidism. In athyroid mice, the hypertrophy [6] of the cartilage was never so marked as in mice with intact thyroids, and severe ulcerative lesions were not observed in the



OSTEOARTHRITIS AND OSTEOARTHRITIC FEATURES IN MICE OF STRAIN C_{57}BL. ●——● NON-THYROIDECTOMIZED, STOCK DIET; ●-·-·-● NON-THYROIDECTOMIZED, HIGH FAT DIET; ●- - - -● RADIO-THYROIDECTOMIZED, STOCK DIET; ●-o-o-o-● RADIO-THYROIDECTOMIZED, HIGH FAT DIET.

CHART III

TABLE III

FINDINGS IN THE JOINTS OF MALE MICE OF STRAINS DBA AND $C_{57}BL$ WITH INTACT THYROIDS FED THE STOCK AND HIGH-FAT DIET RESPECTIVELY

Strain	Diet	Age Group (*Months*)	No. of Mice	Mean Age (*Months*)	Osteo-Arthritis (*Per cent.*)
Dba	Stock diet	9 to 12	30	9.4	10.0
		13 to 18	40	17.6	32.5
		19+	10	19.7	20.0
Total		9 to 19+	80	14.5	22.5
Dba	High-fat diet	9 to 12	25	9.3	12.0
		13 to 18	33	16.1	33.3
		19+	5	20.4	40.0
Total		9 to 19+	63	14.0	25.4
$C_{57}BL$	Stock diet	9 to 12	36	10.2	8.3
		13 to 18	34	16.8	32.4
		19+	43	23.0	51.2
Total		9 to 19+	113	17.2	31.9
$C_{57}BL$	High-fat diet	9 to 12	43	11.0	23.4
		13 to 18	70	16.7	64.3
		19+	46	22.0	84.8
Total		9 to 19+	159	16.1	59.8

animals studied. It might, therefore, be preferable to refer to these changes as "hypotypical" osteo-arthritic features rather than to refer to them as outright osteo-arthritis. Lesions of this type are, for lack of a better term, designated as mixed arthropathies, or as arthropathies with osteo-arthritic features (Fig. 5). These changes were particularly frequent in radiothyroidectomized mice fed the high-fat diet.

INCIDENCE OF ARTHROPATHIES

The incidence of the arthropathies as found in the animals of the various experimental groups are given in Tables II and III and are illustrated in Charts I, II, and III.

ATHYROID JOINT DISEASE

Strain Dba

At a mean age of twelve months, 7.7 per cent. of the stock-fed animals had athyroid joint disease, while as many as 73.3 per cent. of mice of corresponding age fed the high-fat diet were thus affected. Similarly, in mice of the second age group (mean ages 16.6 and 16.0 months), the incidence of the athyroid joint disease was 64.0 per cent. and 97.6 per cent., respectively, for mice fed the two diets. Mice of the oldest age groups showed the same trend: At a mean age of 19.3 and 19.0 months, respectively, 63.6 per cent. of the stock-fed animals and all of the mice which had been fed the high-fat diet had joint disease. The over-all incidence for stock-fed mice of this strain was 49.0 per cent. at the mean age of 16.0 months, and 91.9 per cent. at the mean age of 15.2 months for the mice which had been fed the high-fat diet.

Strain $C_{57}BL$

The incidence of athyroid joint disease in stock-fed animals increased from 10.0 per cent. at 12.0 months to 47.9 per cent. at 17.7 months of age, with a mean of 38.2 per cent.

for mice of all ages (mean age 17.8 months). It may be noteworthy that mice of this group lived to the age of twenty-four months, while none of the mice which had been fed the high-fat diet survived the age of eighteen months. In mice consuming the high-fat diet and only twelve months of age, the incidence of athyroid joint disease was more than three times (33.3 per cent.) that seen in stock-fed animals (10.0 per cent.), and during the next six months of life it rose to 65.7 per cent., resulting in an over-all incidence of 57.4 per cent. at a mean age of 15.5 months in mice fed the high-fat diet. By contrast, the over-all incidence of athyroid joint disease in stock-fed animals was 38.2 per cent. at 17.8 months of age.

Feeding of the high-fat diet thus increased the incidence and accelerated the onset of athyroid joint disease in mice of both strains. A peak incidence of the arthropathy was usually observed seven to ten months after injection of I^{131}; thereafter, no noticeable intensification of the changes occurred. The effect of the fat-enriched diet was more conspicuous in Dba mice in that it increased the incidence by about 85 per cent. over that seen in stock-fed animals, while in $C_{57}BL$ mice this difference amounted to only 50 per cent. The strain difference in the skeletal response to the high-fat diet acquires additional significance in view of the fact that in $C_{57}BL$ mice the lesions were by far less severe than those in Dba mice.

OSTEO-ARTHRITIS AND ATHYROID JOINT DISEASE WITH OSTEO-ARTHRITIC FEATURES

Pure forms of advanced osteo-arthritis were not seen in radiothyroidectomized mice. However, there were manifestations of less advanced osteo-arthritic lesions, usually seen in association with athyroid joint disease.

Strain Dba

Of stock-fed mice with intact thyroid glands, 22.5 per cent. had osteo-arthritis at a mean age of 14.5 months; feeding of a high-fat diet resulted in a similar incidence (25.4 per cent.) at a mean age of 14.0 months. In stock-fed mice radiothyroidectomized at the age of six months, osteo-arthritic features were twice as frequent (47.1 per cent.) as they were in mice with intact thyroid glands (22.5 per cent.), while athyroid mice fed the high-fat diet had at 15.2 months of age an 88.5 per cent. incidence of "mixed arthropathy".

Strain $C_{57}BL$

Of stock-fed mice with intact thyroid glands, 31.9 per cent. had osteo-arthritis at a mean age of 17.2 months; in those fed the high-fat diet, the incidence of such lesions was 59.8 per cent. at 16.1 months of age. In stock-fed mice, radiothyroidectomized at the age of six months, the incidence of osteo-arthritic changes was increased over that seen in untreated controls: 50 to 65.2 per cent. of the mice were affected at various ages, the over-all incidence being 60 per cent. at a mean age of 17.8 months as compared with 31.9 per cent. at a mean age of 17.2 months in mice with intact thyroid glands. This constitutes an approximately twofold increase over the incidence seen in stock-fed mice with intact thyroid glands. Feeding of a high-fat diet to athyroid mice raised the incidence of arthropathies with osteo-arthritic features from 60 per cent. to an over-all high for this strain of 93.6 per cent. at a mean age of 15.5 months.

DISCUSSION

The results of the present experiments fit together with previous findings to form a pattern indicating the role of thyroid secretions in the pathogenesis of certain articular lesions. The following discussion compares the observations in mice of the two strains tested (Table IV).

1.* Whether or not strain differences in the incidence of spontaneous osteo-arthritis

* The numbers at the beginning of the following paragraphs refer to the numbers in Table IV.

TABLE IV

SUMMARY OF OBSERVATIONS

Strain with Inactive Thyroid Glands ($C_{57}BL$)	Strain with Active Thyroid Glands (Dba)
1. High susceptibility to spontaneous osteo-arthritis.	1. Low susceptibility to spontaneous osteo-arthritis.
2. Marked intensification of osteo-arthritis by high-fat diet.	2. Slight intensification of osteo-arthritis by high-fat diet.
3. Low susceptibility to athyroid joint disease.	3. High susceptibility to athyroid joint disease.
4. Osteo-arthritis decreased if radiothyroidectomized early in life.	4. Osteo-arthritis decreased if radiothyroidectomized early in life.
5. Athyroid joint disease with osteo-arthritic features increased if radiothyroidectomized in adulthood.	5. Athyroid joint disease with osteo-arthritic features increased if radiothyroidectomized in adulthood.
6. Slight intensification of athyroid joint disease with osteo-arthritic features by high-fat diet.	6. Drastic intensification of athyroid joint disease with osteo-arthritic features by high-fat diet.

are in any way related to strain differences in thyroid activity remains undecided. The present experiments failed to answer this question because of the intervening athyroid arthropathy.

2. High-fat diets accelerate skeletal development and aging and injure the articular cartilage.[8] Differences in thyroid activity may partly account for strain differences in the skeletal response to the high-fat diet, for in hyperthyroid Dba mice the excess fat is metabolized more rapidly than it is in euthyroid $C_{57}BL$ mice; and in Dba mice the fat is thus prevented from damaging the tissues. This assumption seems to be supported by the findings discussed in paragraph 6 of this discussion. The relative susceptibility of the two strains to the high-fat diet was modified by radiothyroidectomy.

3. The role of thyroid deficiency in juvenile arthropathies has been known for some time[3,4,5,9] and some of its experimental aspects have been described recently[7]. Strain differences in the susceptibility of mice to athyroid joint disease may be related to strain differences in thyroid function: $C_{57}BL$ mice are adapted to small amounts of thyroid hormone and are, therefore, less sensitive to loss of thyroid secretions than are Dba mice, the homeostatic mechanisms of which are adapted to high levels of thyroid hormone. Correspondingly, in $C_{57}BL$ mice, fewer and less severe lesions will develop after radiothyroidectomy, and they will be seen at a later age than those in Dba mice.

4. That osteo-arthritis failed to develop in mice of both strains after radiothyroidectomy performed early in life has been attributed to the inhibition of articular growth and development which is caused by thyroid deficiency. Apparently only fully grown and matured cartilage is an adequate substratum for the development of osteo-arthritis.[2] Moreover, processes of growth and ossification are essential features in the histogenesis of osteo-arthritis, and an inhibition of the former may thus lead to an attenuation of the latter.

5. If radiothyroidectomy had been performed after cessation of linear growth, lesions with osteo-arthritic features were observed in mice of both strains. Notwithstanding the low degree of these "hypotypical" lesions, they were more numerous than the similar, but advanced, lesions in mice with intact thyroid glands. In all likelihood these changes do not merely represent complications of athyroid joint disease; otherwise it would be difficult to understand why they were so infrequent in mice thyroidectomized early in life. Rather, these osteo-arthritic changes seem to be contingent on an advanced stage of development of the articular cartilage at the time of thyroidectomy.

6. High-fat diets produced injury to the articular cartilage of the growing animal, as

well as to that of the adult animal; this occurred in thyroidectomized animals, as well as in mice with intact thyroid glands. These changes consisted essentially in a stimulation of growth and degeneration; they are in certain respects opposed to the effects of thyroidectomy. It is, therefore, not surprising that excessive fat in the diet would to some extent compensate for the deficiency of growth due to hypothyroidism. This compensation is slight, but it may account for the increased incidence of both growth and regressive changes in the joints of animals fed the high-fat diet as compared with those in stock-fed animals.

Strain differences in the articular response to a high-fat diet are not abolished by radiothyroidectomy; they are reversed. Although the total incidence of arthropathy was similar in mice of both strains, the articular lesions were by far more severe in Dba mice than those in C_{57}BL mice. Thus C_{57}BL mice, which are usually more susceptible to the harmful effects of high-fat diets than are Dba mice, become less so; while Dba mice, with a low natural susceptibility to a high-fat diet, acquire a high susceptibility following radiothyroidectomy. This indicates that the thyroid hormone may play a major role in the skeletal response to the high-fat diet of certain individuals with a high level of thyroid activity, but plays only a minor part in those in whom the thyroid gland is ordinarily not very active.

SUMMARY

In mice of various strains the structure and function of the thyroid gland vary, mice of strain Dba having comparatively active glands and mice of strain C_{57}BL possessing comparatively inactive thyroid glands. In C_{57}BL males, a high-fat diet increased the incidence and advanced the onset of degenerative joint disease, while in Dba males, the fat-enriched diet failed to exert significant effects on the articular structures. It was assumed that differences in thyroid activity might be related to the strain differences in the response to the high-fat diet. The fat-enriched ration was, therefore, fed to adult mice of both strains, after their thyroid glands had been destroyed by injection of I^{131}. Following this treatment, the response of the mice of the two strains was reversed. In the absence of thyroid secretions, C_{57}BL mice became less susceptible than Dba mice, while Dba mice became more susceptible to the injurious effect of the high-fat diet than Dba mice with intact thyroid glands.

Radiothyroidectomy also produced characteristic articular changes, which were different from degenerative joint disease and which were designated "athyroid joint disease". The susceptibility to this lesion likewise varied with the thyroid activity characteristic of the strain. Dba mice showed a high incidence and a severe degree of this disease, while C_{57}BL mice were less frequently affected and showed only low-grade lesions. A fat-enriched diet, in turn, adversely influenced the course of athyroid joint disease in both strains of mice.

Thus the thyroid hormone plays a major role in the development of the growing joint and in the maintenance of the adult articular structures under normal conditions, as well as under abnormal conditions. The extent of this influence varies with the degree of thyroid function characteristic of the particular strain of mice or of the individual.

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DISCUSSION

Care of Open Injuries of the Hand and Fingers

(Continued from page 526)

histogram showing the healing rates of the lacerations and of the open contusions. He will see that there is a considerable scatter to the right of the mean healing days of eight and seventeen, respectively, of the two lesions. This indicates many results which Dr. Koch would call very poor indeed. A number, I am sorry to have to report, took several weeks and some three or four months to heal. Indeed the average healing times for the lesions with soft-tissue loss requiring repair by flaps or free grafts was about a month—a figure on which we, and indeed anybody, would hope to improve.

Dr. Koch: How do you carry out antibiotic treatment?

Mr. Clarkson: Most patients are given antibiotics as a routine — three to four daily injections. It is possible that, when they attend the injection room simply for injection and not for attention to the wound (which may be left undisturbed for intervals of two to five days), this is not reported as a separate attendance. The figures in the chart of mean healing days and mean attendances are a very fair picture of the treatment given and the results.

Dr. Thomas W. Stevenson, New York, N. Y.: I would like to carry the thought of Dr. Koch one step further. Previously I had spoken to Mr. Clarkson very briefly about one small aspect of the subject. It appears that in his reconstructive care of the hand he frequently permits the patient to go home after the application of a graft. I dislike having the patient out of my control in the early period when various accidents of normal living can occur. Most memorable in my experience was a child who had a saturated dressing on his hand as a result of playing with a toy boat in a toilet bowl at home. My feeling is that, when I have taken the necessary time to put on a graft, I am obligated to safeguard the patient from an infection in the hand. Also, it is certain that dressings are less subject to derangement while a patient is at rest in a hospital and that elevation is beneficial to healing. In addition to the patient's interest I am anxious to maintain my own "batting average" as much as possible and to facilitate the "take" of the graft and the rapid healing of the wound. On the other hand it is obvious that Mr. Clarkson has obtained good results with early ambulation; therefore, perhaps we should take another look at this question. It certainly would ease the hospital bed situation if we could strike a happy medium. I fear, however, that the human element will deprive us of too much latitude in this matter.

Mr. Clarkson: I like to have examples of reparative surgery for teaching material. It is, therefore, quite true that I extend the scope of reparative work undertaken on out-patients beyond what is usual, and possibly beyond what is wise. There are of course beds available for injured patients who need them, but, if a patient can be successfully treated as an out-patient without courting unnecessary pain or risk, it is economically sound that this should be done.

CLINICAL EVALUATION OF FREEZE-DRIED BONE GRAFTS *†

BY CAPTAIN CHALMERS R. CARR, *Medical Corps, United States Navy*
AND LIEUTENANT COMMANDER GEORGE W. HYATT, *Medical Corps, United States Navy*

From the Orthopaedic Service, United States Naval Hospital and Tissue Bank, Naval Medical School, National Naval Medical Center, Bethesda, Maryland

In the continuing search for improved bone-graft materials, Kreuz, Hyatt, Turner, and Bassett, in 1951, reported on the preservation of bone by drying from the frozen state. In this report, freeze-dried homografts were compared in animals with autogenous grafts and with surgical bone defects. The histological phases described were reactive-bone formation, porosity, perivascular-bone formation, and appositional bone growth. The manner of graft incorporation did not appear to differ in any of the transplants studied. The notable difference was in the rate of healing, for the freeze-dried grafts were incorporated at a slightly slower rate than their autogenous counterparts. At the time of the original report, freeze-dried homogenous bone grafts had been used by these authors in six human patients.

In 1951, the senior author of this paper succeeded Captain Frank P. Kreuz as Chief of the Orthopaedic Service, United States Naval Hospital, Bethesda, Maryland, and he has been privileged to pursue the clinical investigation of this form of grafting material. Approximately fifteen individual surgeons have used freeze-dried homogenous bone under his direction and 119 additional patients have had freeze-dried bone grafts inserted since 1951. These, with the six cases reported earlier by Kreuz and his associates, form the basis for this report.

At the outset, this study was established as a clinical research project, and each recipient of the grafts was acquainted with the nature of the study, and permission for the use of the material was given. Because of the shifting nature of the military population, an intensive follow-up system was established and the records have been maintained by the Tissue Bank of the Naval Medical School, National Naval Medical Center **.

During the period we have been using this material, more than 100 additional bone-grafting procedures have been done by collaborating military and civilian surgeons. These are not included in this report but will be included in a more comprehensive future study.

BACKGROUND

The use of stored frozen homogenous bone transplants was introduced by Bush and Garber and by Wilson. These reports, with that of Inclan in 1942, were the first noteworthy clinical advances in the use of homogenous bone since the publication of the work of Ollier in 1867. The long-term clinical evaluation of patients in whom frozen homogenous transplants had been used indicated sufficient success to continue its use. In many hospitals, the bone bank has become a fixed accessory. In this same period of clinical orthopaedic development, the Korean conflict found military surgeons once again working with

* Read at the Annual Meeting of The American Orthopaedic Association, Bretton Woods, New Hampshire, June 9, 1954.

† The opinions herein are those of the authors and are not to be construed as reflecting wholly or in part those of the Bureau of Medicine and Surgery or of the Navy Department.

** Special credit in preparing the material for review and for exhaustive record-keeping should go to the officers in charge of the Tissue Bank during this period, Lieutenant T. C. Turner, Medical Corps, United States Naval Reserve, Lieutenant W. R. Strong, Medical Corps, United States Naval Reserve, Lieutenant R. G. Kindred, Medical Corps, United States Naval Reserve, and to those military and Veterans Administration facilities which have cooperated in locating and studying the cases. Without such effort, our follow-up studies would have been inadequate.

the trauma and reconstructive surgery of war wounded. In view of this, the Orthopaedic Service of the United States Naval Hospital at Bethesda began a study of stored homogenous bone transplants. The investigation of preserving bone by freeze-drying was decided upon. This principle had been successfully applied to the preservation of human blood plasma during World War II and was suggested as a likely method of storing bone.

As the clinical investigation developed, it became evident that a sustained source of bone was of prime necessity. To provide this and to evaluate the clinical use of bone homografts and later of tissue homografts, the Tissue Bank was designed and was installed as a research and development project of the Naval Medical School [4]. The junior author of this paper was the first Officer in Charge of the Tissue Bank. The Experimental Surgery Division of the Naval Medical Research Institute provided the basic experimental design which led to the development of the different phases by the Tissue Bank, with the clinical services of the Naval Hospital providing the final and conclusive tests *.

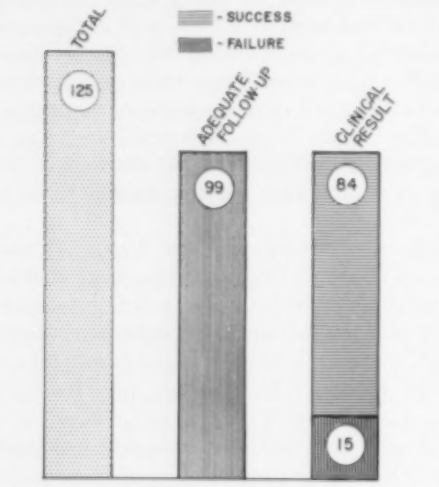


CHART I

The Tissue Bank provided for sterile postmortem procurement of bone, in addition to facilities for chilling, freezing, and freeze-drying. Vascular surgeons have adopted the freeze-drying method, as developed by this group, for the storage of arterial homografts [1]. The experimental surgical evaluation of freeze-dried tendon, fascia, and dura is currently being investigated by the research members of the team at the Naval Medical Research Institute.

The grafts used in the cases on which this report is based were procured through sterile postmortem surgical procedures. The harvesting average is thirty-five one-ounce cortical-bone deposits and thirty-five one-ounce, ground cancellous-bone deposits per cadaver. The reject rate from bacterial contamination averages 8 per cent. Immediately after procurement, the bone is placed in a glass unit and is stored at −70 degrees centigrade prior to processing. The temperature in the freeze-dryer is approximately −50 degrees centigrade when the bone is placed on the drying shelf. The vacuum is obtained from a mechanical oil pump that functions at 30 to 150 micra. When all but approximately 10 per cent. of the residual moisture has been released from the bone, the temperature of the drying plate is gradually elevated until it reaches room temperature. When a residual moisture of from 1 per cent. to 5 per cent. has been attained, the bone is removed from the unit and is capped under vacuum. Throughout the processing and final capping, the bone remains in its original glass unit. With freeze-dried bone, the vacuum is required to prevent absorption of moisture from the atmosphere. The average freeze-drying cycle for bone takes two weeks.

The use of the cadaver as the source of bone permits the removal of select homograft material. Routine operative approaches during the sterile postmortem are used to remove bone. The entire ilia are removed, and the heavier cancellous sections are converted into iliac strips, two by four by eight to ten centimeters, the remainder of the bone being ground and deposited as one-ounce units by volume. The tibiae and femora are removed com-

* The encouragement, support, and administrative direction of the Commanding Officers of the National Naval Medical Center, the United States Naval Hospital, the Naval Medical School, and the Naval Research Institute have been vital and sustaining factors.

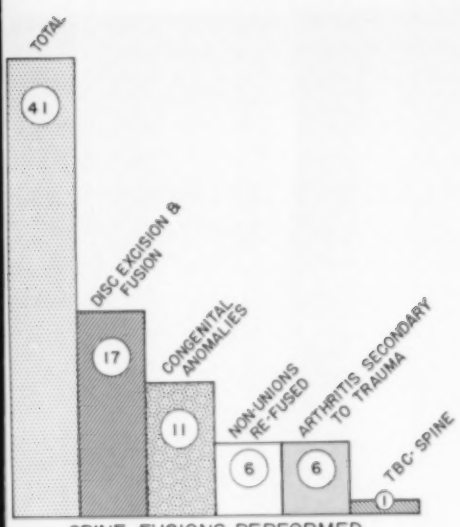


Chart II

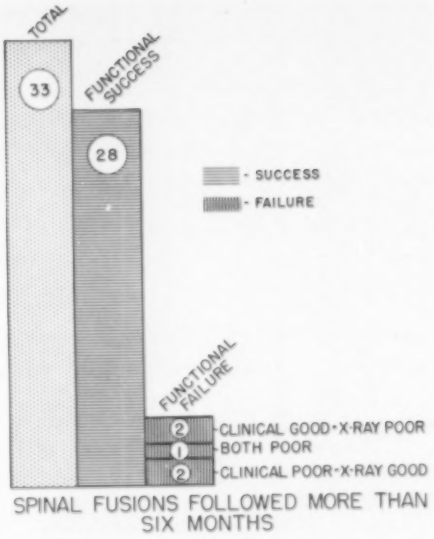


Chart III

pletely, except for the areas adjacent to the joint articulations. These shafts are converted into cortical grafts from two to three centimeters in width and ten to twelve centimeters in length. The scapulae are also completely removed, are ground, and are deposited as one-ounce units. In special cases, a specific section is removed, such as an intact talus or metacarpal bone.

It is our experience that these methods permit the orthopaedic surgeon a wide selection of grafting material. Freeze-dried bone is moderately friable in its dry state; however, it will apparently regain its elastic physical properties when physiological saline solution is added to the deposit unit preoperatively. Cortical bone is usually reconstituted in this

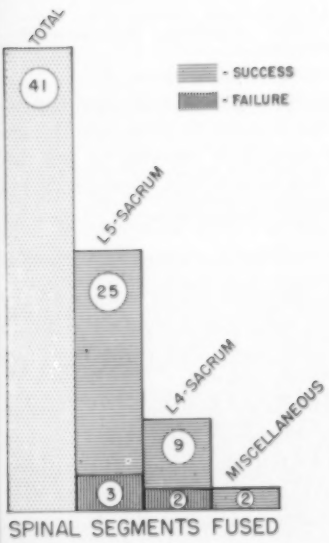


Chart IV

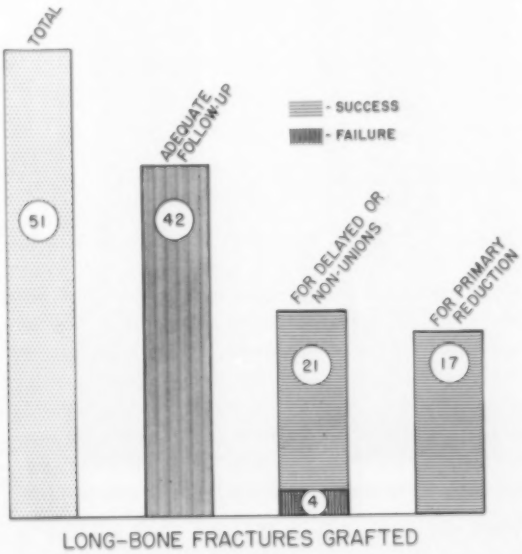


Chart V

FIG. 1-A

FIG. 1-B

FIG. 1-C

Fig. 1-A: Case 1. Delayed union and malalignment in simple fracture of the tibia and fibula after four months of plaster immobilization.

Fig. 1-B: Five months after open reduction and onlay-grafting with freeze-dried cortical bone.

Fig. 1-C: Eighteen months after bone-grafting. Note remodeling and complete graft incorporation.

manner overnight. The ground cancellous bone is easier to pack into the operative area if it remains in the dry state. This bone is then reconstituted in the patient's hematoma.

CLINICAL RESULTS

In this series of 125 cases, we have obtained adequate follow-up data in ninety-nine cases. This varies from five to thirty-six months.

The clinical failures in this group number fifteen (Chart I); but when factors not related to the graft have been eliminated, the graft failures are nine (9.68 per cent.) (Chart X). We shall analyze these failures and detail the differences between the *clinical result* and the *graft result*.

FIG. 2-A

FIG. 2-B

FIG. 2-C

Fig. 2-A: Case 2. Non-union in the second metatarsal shaft secondary to a missile wound.

Fig. 2-B: Eight months after open reduction and the insertion of a 2.5-centimeter section of the whole shaft of a freeze-dried infant femur as a key graft.

Fig. 2-C: Twenty-seven months after bone-grafting. Note the re-formation of the metatarsal shaft.

These cases are divided into:

1. Spine fusions,
2. Fractures of long bones,
   a. Delayed union and non-union,
   b. Recent fractures,
3. Arthrodeses (except spine fusions),
4. Bone cavities packed.

SPINE FUSIONS

Forty-one spine fusions were performed; and all, except one, involved the lumbar spine. The indications are enumerated in Chart II.

In analyzing spine fusions, it is difficult to determine the criteria for evaluating the success of the graft. Therefore, the authors have relied upon their clinical estimate of the result expected from spine fusions done by commonly employed techniques. In the authors' hands, the procedure consists in a cancellous-chip (Hibbs) type of fusion. This technique was employed in all of their fusions, with the addition, in three instances, of large strips of cortical bone to reinforce the chips and splintered ribs. In the patients followed for over six months, there were twenty-eight successful results and five failures (15 per cent.) (Chart III). In this group of failures, two were clinical failures, inasmuch as the symptoms had not been relieved, although there was x-ray evidence of satisfactory healing. In two patients, in one of whom there was symptomatic spondylolisthesis, there were excellent clinical results with relief of symptoms. However, there was x-ray evidence of pseudarthrosis in one at the end of two years, and, in the other, there was clinical and roentgenographic evidence of failure of fusion. We acknowledge that the use of clinical evaluation in deter-

FIG. 3-A

Case 3. Distraction non-union of the humerus.

mining success of these fusions depreciates their statistical validity. It is probable that only surgical examination of the fused area can conclusively demonstrate fusion. The authors have not made use of this method but have relied on multiview roentgenograms and physical evaluations. Inasmuch as this paper is primarily concerned with the fate of freeze-dried bone grafts, the authors consider that these data, based on this evidence, will be informative. The relationship of failures to the segments fused and the ratio of segments fused to the total attempts is depicted in Chart IV.

We shall not enumerate the healing time in all of our patients, as it is impossible to obtain mutually objective and satisfactory standards for comparison. It is the authors' impression that bone healing was not measurably retarded in the successful cases, and postoperative discomfort was minimized by the absence of additional donor incisions. Of the forty-one patients subjected to spine fusion, there were two with wounds which drained postoperatively. Both wounds cleared without evidence of bone sequestration. After eight months in one and twelve months in the other, no osteomyelitis was evident.

FRACTURES OF LONG BONES

In the treatment of fractured long bones, freeze-dried bone grafts were used in fifty-one patients. An adequate follow-up was available for forty-two (Chart V). In twenty-five, there was pre-existing delayed union or non-union which required surgical intervention. In seventeen, grafts were inserted as part of the open reduction of fresh fractures. In all of these, the fractures united satisfactorily. There were four failures in the group with pre-existing delayed union or non-union.

Delayed Union and Non-Union

Operative procedures for delayed union or non-union of fractures were carried out twenty-five times. Eleven were for old compound fractures in which there had been drainage and scarring; eight of these had been caused by gunshot wounds. In this group, there were four failures. The failures after grafting occurred in the radius twice, the ulna once, and a metacarpal once. All of these surgical failures were in areas where there had been infection previously.

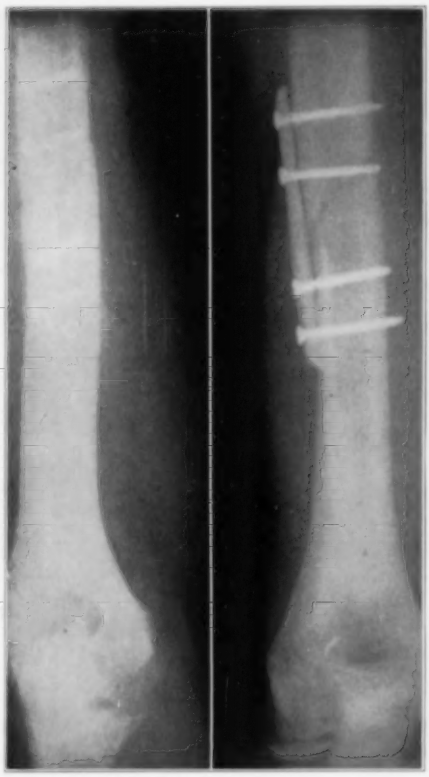


FIG. 3-B

FIG. 3-C

Fig. 3-B: After open reduction, fixation with a freeze-dried cortical onlay graft, and packing with cancellous freeze-dried chips around the fracture site.

Fig. 3-C: Result nine months later.

CASE 1, W.J.G., a twenty-year-old seaman, United States Navy, had been injured in an automobile accident on January 27, 1952, and had sustained a simple fracture of the tibia and fibula. The leg had been immobilized in a cast for four months (Fig. 1-A). At this time it was evident that delayed union had developed. The patient was transferred to our Service for additional treatment. On June 6, 1952, an open reduction with the insertion of an onlay homogenous bone graft was performed. Rather slow but progressive healing of the fracture occurred following this grafting procedure (Fig. 1-B). By November 1952, his cast had been exchanged for a walking brace; and, by January 1953, the fracture had completely healed (Fig. 1-C).

CASE 2, W.S.R., a corporal in the Marine Corps, twenty-eight years old, had been wounded in the foot by shell fragments on November 3, 1950. Non-union of the fracture of the second metatarsal of the right foot had subsequently developed (Fig. 2-A). On July 25, 1951, a small portion of a freeze-dried infant femur was cut to shape and was fitted into the site of the non-union as a key graft. The patient was discharged from the Service in March 1952. Roentgenograms obtained twenty-seven months later showed that he had complete consolidation and re-formation of the metatarsal shaft (Fig. 2-C).

CASE 3, M.A., a male, fifty-one years old, had distraction non-union of the humerus. An intramedullary-rod and single-screw fixation (Fig. 3-A), coincidental with lysis of an injured radial nerve, had been done primarily. The fracture fragments were apposed and were held with a cortical onlay graft, with cancellous chips being placed between the fractured ends (Fig. 3-B). Union was slow but progressive. Figure 3-C shows the graft during the healing phase.

Onlay-grafting for stability, as well as for osteogenic stimulus, is especially useful in fresh fractures and in non-weight-bearing bones. The necessity of using rigid metallic

plates is avoided. We have found that these reconstituted freeze-dried grafts are strong enough to give adequate strength in the early weeks of healing.

Case 4, M.L.R., a marine, twenty-eight years old. Non-union developed with loss of substance of both bones of the forearm (Fig. 4-A). His original wounds (combat incurred) had been extensive and had involved the ulnar and median nerves. Skin coverage had apparently controlled the pre-existing infection. The ulna was pinned and a graft was inserted on March 4, 1952; a graft was inserted in the defect of the radius on April 1, 1952—six months after his original injury (Fig. 4-B). The ulnar graft was successful, but the graft to the radius was not. Information received from the Veterans Administration Hospital to which he had been transferred indicated that reconstruction of the radius had failed. Surgical synostosis of the radius and ulna was required (Fig. 4-C).

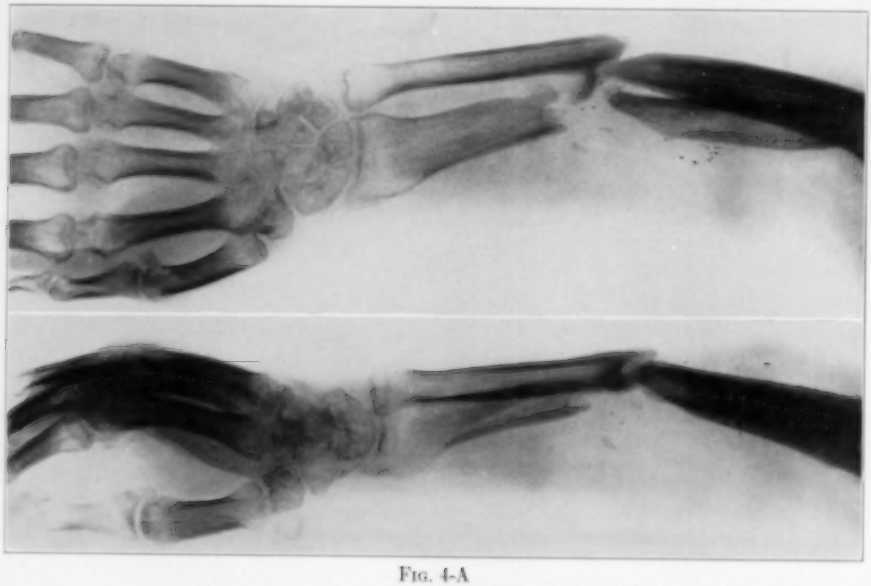


Fig. 4-A

Case 4. Non-union of the ulna and radius secondary to missile wounds.

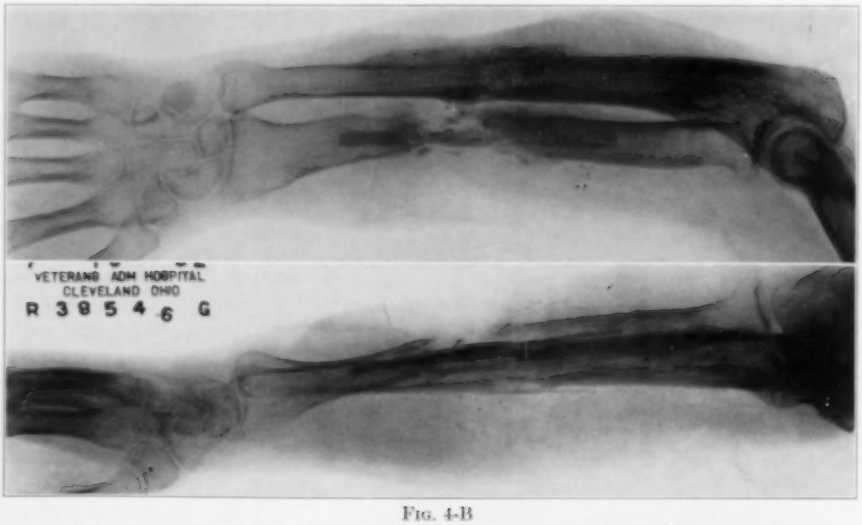


Fig. 4-B

Note graft incorporation with healing of the ulna. There is dissolution of the graft applied to the radius.

FIG. 4-C

Surgical synostosis accomplished between the radius and ulna sixteen months after the last grafting procedure had failed.

CASE 5, L.M.McG., a female, thirty-seven years old, had suffered a compound comminuted fracture of the mid-shaft of both bones of the left forearm in 1940. Original fixation had been by means of metallic plates, and a draining wound had resulted which had required the removal of these plates. No drainage had developed subsequently, in spite of the fact that she had undergone five additional operations. In October 1941, there had been a repetition of the open reduction and both bones had been fixed with metallic plates. In May 1945, the ulnar plate had been replaced. In 1946, the forearm had been manipulated, as the plates had become bent. In 1947, the plates had been removed and had been replaced, and, in 1950, bone grafts had been applied to both bones of the forearm. At that time, bone had been used from the patient's own left ilium. On February 20, 1953, freeze-dried bone grafts were applied to both forearm bones, with a separate approach used for each bone. The ulna was stabilized with a Rush intramedullary nail, and a spline graft of homogenous bone was slotted into the radius. Both fracture sites were packed circumferentially with freeze-dried cancellous bone chips. Progressive examinations at regular intervals showed that another non-union of the radius was developing, as the graft here was disappearing. It appeared, however, that union was progressing at the ulna. When last examined in March 1954, thirteen months following surgery, she had tentative union of the ulna, but non-union of the radius was developing.

Recent Fractures

There were seventeen patients in whom homogenous freeze-dried bone grafts were used in the primary reduction of fractures. These took the form of either cancellous-bone chips across the fracture site, in conjunction with intramedullary nailing, or cortical-bone onlay grafts for fixation. Inasmuch as most fresh fractures heal if they are reduced and are immobilized, little can be determined from these procedures. However, the use of cortical onlay grafts, easily obtained from the shelf, is favored for fresh fractures which require accurate apposition and fixation while callus forms.

CASE 6, J.A.S., a male, twenty-three years old, incurred an unstable fracture at the distal fourth of the right radius in August 1953. A cortical strip of bone, machined to fit the radius, was attached and was fixed with four stainless-steel screws. Progressive union was evident. He returned to full duty four months later. Final roentgenograms, made in January 1954, showed a faint fracture line, but the graft was consolidated and the fracture was stable.

The authors believe that when bone is used, even for firm fixation, there is less likelihood of non-union from absorption than when rigid metallic plates are used. It apparently forms a trellis for bridging callus.

CASE 7, J. B., a male, twenty-two years old, had sustained a simple displaced fracture of the distal ends of both bones of the left forearm on July 17, 1952. Because of complicating head, chest, and abdominal

injuries, it had been impossible to give adequate attention to the fracture before July 28. In the interim he had been treated by traction which was unsuccessful in controlling the position of the fracture fragments. On August 15, open reduction of the fracture was performed. The fracture of the radius was fixed by means of a freeze-dried homogenous cortical onlay bone graft, 6.5 centimeters long; two screws were placed through each fracture fragment. The ulnar fracture was fixed by means of an intramedullary rod (Fig. 5-B). Progress was satisfactory, and roentgenograms showed progressive healing of the fractures. The patient was returned to duty on January 29, 1953, the intramedullary nail in the ulna having been removed on December 17, 1952. Examination eighteen months later showed excellent healing and consolidation of both fractures of the forearm bones.

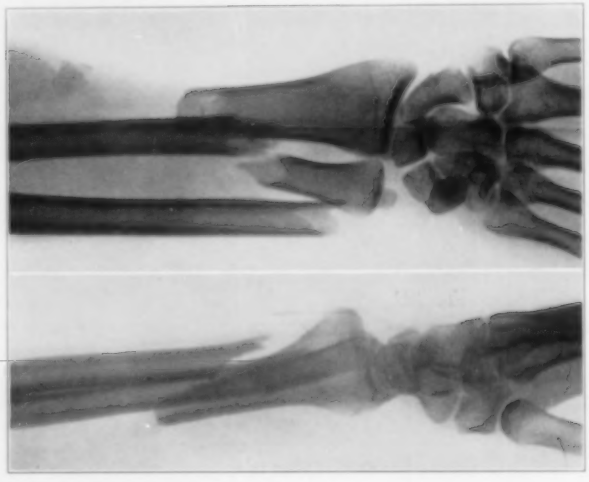


FIG. 5-A

Case 7. Simple fracture of the radius and ulna with gross displacement.

CASE 8, R.E.J., a male twenty-five years old, had been injured in a motor-car accident. An unstable oblique fracture of the tibia and an associated fibular fracture had resulted. Two attempts at maintaining reduction by plaster cast had been unsuccessful.

On March 28, 1951, a cortical onlay graft was used to stabilize reduction. Union was extremely slow, and it was not until September 1952 that cast protection was removed. (In this area and in this type of fracture non-unions are not uncommon.)

Roentgenograms made in May 1953 (eighteen months after surgery) showed excellent healing and the incorporation of the bone graft.

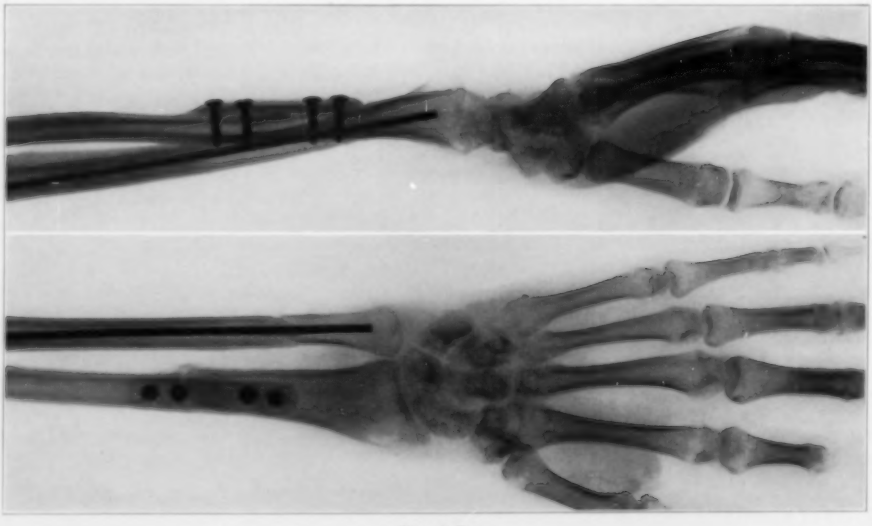


FIG. 5-B

Three months after open reduction and fixation of the radius with a freeze-dried cortical onlay graft. The ulna was secured with intramedullary fixation and freeze-dried cancellous chips were packed completely around the fracture site.

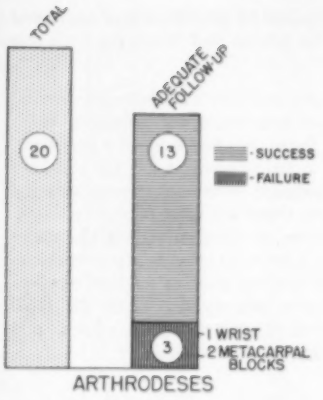


CHART VI

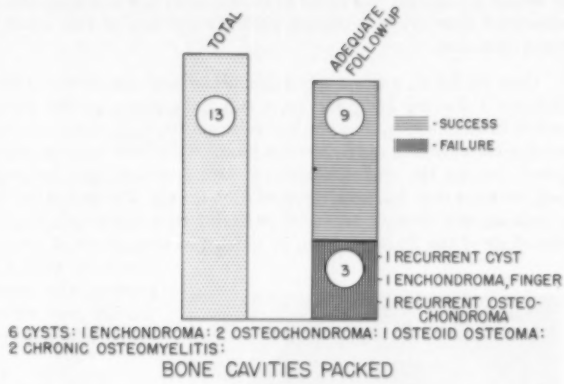


CHART VII

ARTHRODESES

A total of twenty arthrodeses have been performed in this series. We have an adequate follow-up on sixteen. Thirteen are classified as successes and three as failures (Chart VI). The failures occurred in one wrist fusion and in two metacarpal bone blocks for paralyzed hands. The wrist fusion and one of the bone blocks were in the same patient. The failure in this patient resulted from a complete wound breakdown, and slough of the bone grafts occurred in a neurotrophic hand, secondary to a combat wound. The knee fusions were successful; one was performed in conjunction with intramedullary-pin fixation. Two others were compression arthrodeses. The two knees in which a compression type of arthrodesis was done had previously been infected; one wound was left open and was drained for a time, following the procedure, but fusion eventually occurred. The two hip arthrodeses were of the Trumble type, and both were successful. One hip was fused because of joint destruction secondary to old osteomyelitis, and the other was fused because of recurrent dislocation secondary to a fracture-dislocation.

CASE 9, L.E.T., a discharged corporal, had originally suffered a compound fracture of the bones of the forearm and a nerve injury. There had been, in addition, a complicating infection with gas bacillus. This had resulted in an almost useless arm, but some finger motion remained. On October 2, 1953, he underwent an arthrodesis of the left wrist and a bone block of the first and second metacarpals of the left hand in the position of opposition. By March 1954, the wrist had become solidly fused. The bone block on the side of

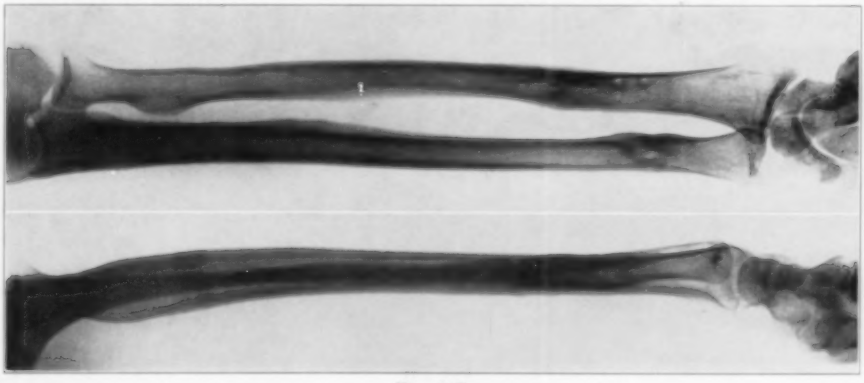
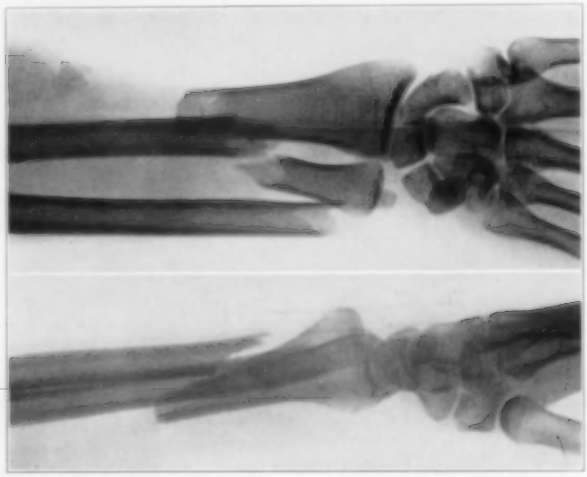


FIG. 5-C

Nineteen months after grafting.

injuries, it had been impossible to give adequate attention to the fracture before July 28. In the interim he had been treated by traction which was unsuccessful in controlling the position of the fracture fragments. On August 15, open reduction of the fracture was performed. The fracture of the radius was fixed by means of a freeze-dried homogenous cortical onlay bone graft, 6.5 centimeters long; two screws were placed through each fracture fragment. The ulnar fracture was fixed by means of an intramedullary rod (Fig. 5-B). Progress was satisfactory, and roentgenograms showed progressive healing of the fractures. The patient was returned to duty on January 29, 1953, the intramedullary nail in the ulna having been removed on December 17, 1952. Examination eighteen months later showed excellent healing and consolidation of both fractures of the forearm bones.



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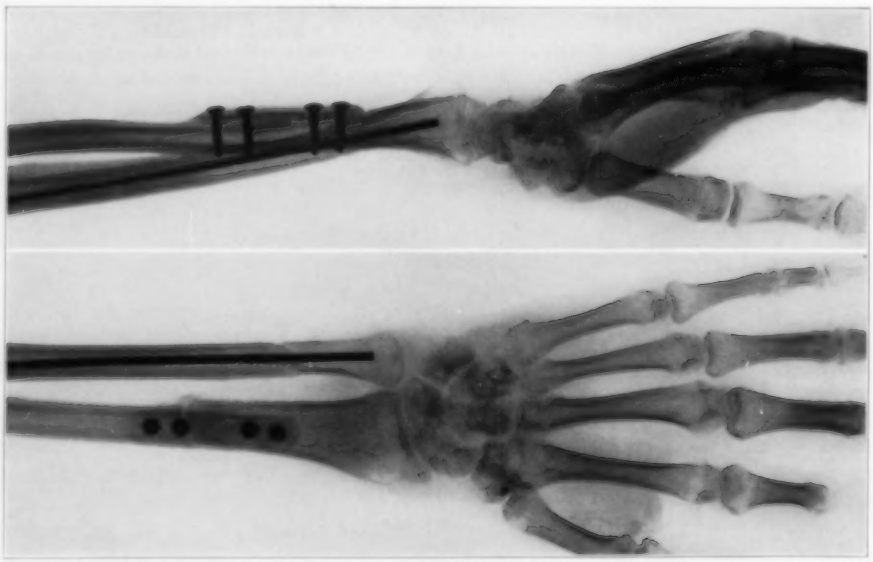

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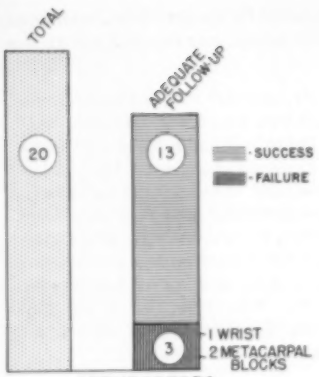
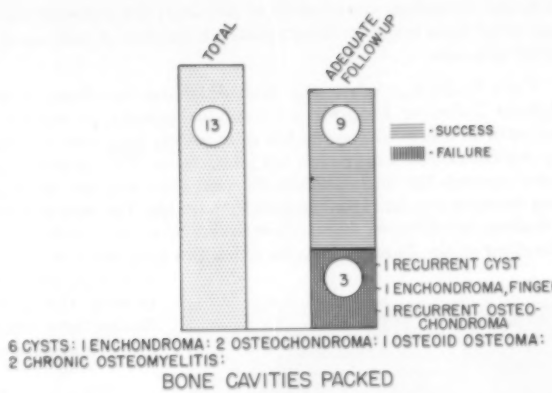


CHART VI



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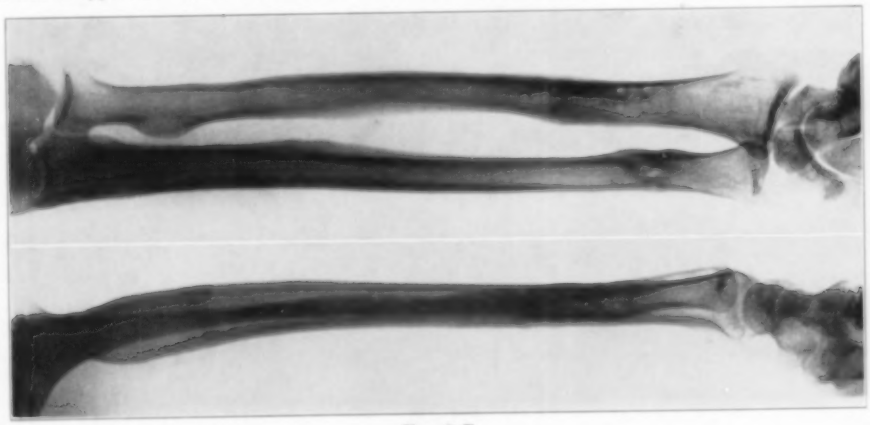


FIG. 5-C

Nineteen months after grafting.

the second metacarpal was found to be ununited; this was surgically repaired by the insertion of additional freeze-dried bone grafts in March 1954. At the time of this report the patient was recovering from this second operation.

Case 10, J.A.S., a veteran, had had a childhood disturbance of the hip, probably a slipped upper femoral epiphysis. Following Army service, a cup arthroplasty on this hip had been attempted elsewhere, which resulted in an infection. The cup had subsequently been removed, but the patient had suffered a persistent, draining osteomyelitis of the left hip joint. About four months prior to the arthrodesis, the hip had been opened through the original Smith-Petersen approach, and the sequestrated bone and necrotic material along the sinus tract had been removed from the hip. The wound had been closed and had healed *per primam*; no drainage had followed. Inasmuch as the infection had remained quiescent, an extra-articular ischiofemoral arthrodesis of the Trumble type, in which two long pieces of cortical bone were used, was performed on March 25, 1953. Union of the graft to the host was progressive. One year after surgery on March 22, 1954, fixation was removed. There was good clinical and roentgenographic evidence of arthrodesis.

Fig. 6-A

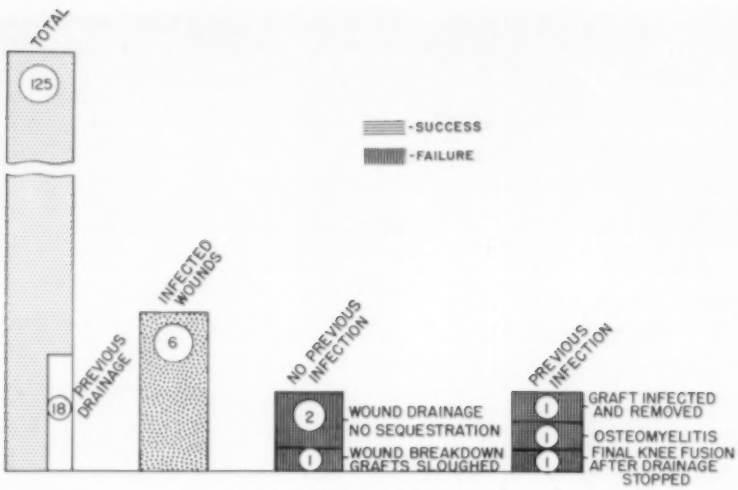
Case 10. The hip joint after a cup had been removed following a joint infection complicating an arthroplasty.

This case is of particular interest, because it gives evidence that freeze-dried bone can be revascularized and can be replaced by normal bone along the pattern of the original graft, even across a space where it is not in total contact along its periphery with host bone. In this patient, the blood supply was excellent and the graft had been placed under moderate compression.

Another Trumble-type arthrodesis was performed for a recurrent posterior dislocation of the hip following fracture-dislocation. Again, the result was excellent at the follow-up examination ten months after operation. The patient has since been lost to follow-up.

Fig. 6-B

A Trumble type of hip arthrodesis in which freeze-dried cortical-bone struts were used. Note the host incorporation of the graft even at points where the graft was not in contact with the host bone.



WOUND HEALING

CHART VIII

BONE CAVITIES PACKED

There were thirteen patients in whom bone cavities were packed, and there was adequate follow-up in twelve. There were nine successes and three failures (Chart VII). In the failures, there was one recurrent simple cyst in the humerus in a growing boy, one enchondroma of the finger which was subsequently fractured and remained ununited, and one recurrent osteochondroma of the tibia. In the last, there had been incomplete removal of a very extensive osteochondroma in the first instance; the bone grafts themselves had seemed to become incorporated into the bone defect, but the operation for which the grafts had been used was not a success. In the patients with successful results, there had been obliteration of five simple cysts, the filling in of a defect left by the removal of an osteochondroma, the filling in of a defect resulting from resection of one osteoid osteoma, and the obliteration of two osteomyelitic cavities in which the drainage had ceased.

FIG. 7-A

FIG. 7-B

Fig. 7-A: Case 13. Fibrous dysplasia of the ilium.

Fig. 7-B: Six months after packing with freeze-dried cancellous chips.

CASE 11, E.L.H., a female dependent patient, twenty-six years old, had been found to have a bone cyst of the right femur just below the greater trochanter, one and one-half years previously, during the course of a pyelographic examination. The patient was of the opinion that in the intervening time the cyst had progressed in size. On January 30, 1952, the cyst was exposed and was drained of its dark amber-colored fluid; and the lining of the cyst was curetted. The cyst was packed with three ounces of freeze-dried, cancellous ground ilium. The wound healed well. The pathological report was "simple bone cyst of the right femur, probably following infarction". Progress in this patient was satisfactory, and seventeen months later, the bone cyst was apparently completely obliterated and the normal architecture of the shaft was re-established.

FIG. 8-A

Case 14. Unicameral bone cyst of the humerus which had undergone four previous fractures.

CASE 12, S.A.H., a two-year-old boy, had a cystic growth just below the right knee joint. An excision biopsy was carried out on February 12, 1952. By this time, the cystic cavity, one by three centimeters, had eroded the lateral shaft of the cortex. The cavity was filled with soft, yellowish-gray fibrous material. Frozen section revealed this to be benign and of fibrous-tissue stroma. The cavity was thoroughly curetted and was filled with cancellous freeze-dried bone. Subsequently the pathologist reported "irregular connective-tissue masses with moderate fibroblastic activity and formation of irregular islands of osteoid and bone". There was no evidence of specific infection or malignancy. The pathological diagnosis was fibrous dysplasia. Two years later, roentgenograms showed obliteration of the cavity and incorporation of the grafts into the host bone.

CASE 13, J.L.M., a female, twenty-eight years old, complained of discomfort of two years' duration in the region of the right hip joint. A firm intracortical mass was located and was removed from the ilium on July 29, 1953. This was reported to be fibrous dysplasia. The cavity was packed with cancellous-bone fragments. Healing was rapid; by January 1954, the lesion had been obliterated and the graft material had been incorporated into the host bone (Fig. 7-B).

CASE 14, R.R.B., a five-year-old male. On July 15, 1953, a unicameral bone cyst (Fig. 8-A) of the proximal end of the right humerus was entered, was curetted, and was packed with cancellous-bone chips. This cyst was known to have been present for at least one year previously, during which time he had had four fractures through the thinned cortex of the bone. The cyst had been expanding and had grown considerably. The pathological diagnosis was unicameral bone cyst. Following operation, the clinical course was entirely favorable, and the boy was discharged. In April 1954, roentgenographic examination revealed that there was additional cystic material growing distally to the original cyst and down the shaft of the humerus. Examination of the site of the packing of the bone graft revealed incorporation of the graft in that area.

FIG. 8-B

FIG. 8-C

Fig. 8-B: Three months later there was evidence of cavity obliteration and graft incorporation.
Fig. 8-C: Nine months after surgery, there was recurrence of the cyst distally.

This case has been classified as a failure because the cyst had not been obliterated. It is recognized that recurrence and continued growth of such cysts in growing children are quite common and often require a number of operations before the patient's full growth has been obtained. It is felt that, in such an instance, bank bone has the advantage of saving multiple additional scars from autogenous donations.

FAILURES

There were fifteen clinical failures (15.2 per cent.) in the ninety-nine cases properly evaluated. The procedures had been carried out primarily for the correction of physical disability. Therefore, we feel it proper to report failures in this manner. However, from the standpoint of the graft material, the six cases in which the graft was not involved in the failure may be eliminated. The cases are: (a) the two in which spine fusions had been performed, with poor clinical results but with satisfactory roentgenographic evidence of bone consolidation; (b) one recurrent osteochondroma—the result of incomplete excision; (c) one recurrent cyst in a growing boy; and (d) two arthrodeses in a neurotrophic hand, with marked postoperative circulatory disturbance and wound slough. These should be classed as technical failures (Chart IX). Thus the over-all failures are nine.

The cases in which the graft had a fair chance of success and did not consolidate were four non-unions (two in the radius), three spine fusions, one enchondroma excised from the metacarpal bone, and one metacarpal bone block. Examples of these have been discussed previously under the appropriate section.

In consideration of these factors, we place the rate of failure in connection with healing of these grafts at 9.2 per cent. (Chart X).

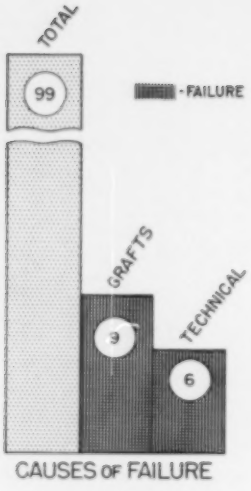


CHART IX

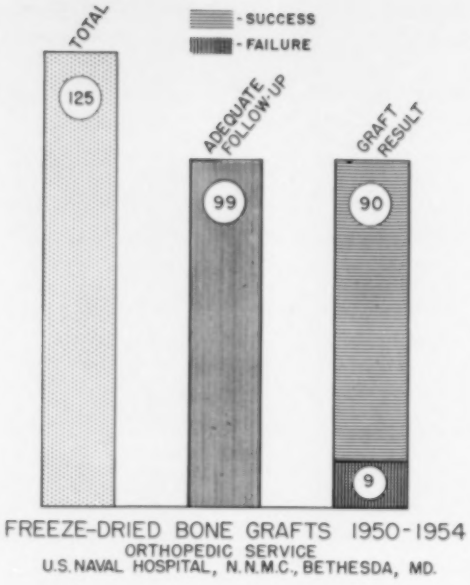


CHART X

WOUND HEALING

The criteria for evidence of graft sterility are cultures of the bone deposits made before the freeze-drying and at the time of surgery. The customary index of wound healing is considered the final and most conclusive test. It must be emphasized that the ultimate development of deep infection with graft sequestration can only be determined by statistically long-term follow-up. This complication, however, is unlikely to occur in those wounds which have healed uneventfully and in which there had been no previous infection.

The results in wound healing are tabulated in Chart VIII. Ninety-nine of the total of 125 operative cases were followed for a sufficient length of time to permit evaluation of the success or the failure of the bone grafts. The entire group was observed until well after the time in which soft-tissue healing normally occurs.

Eighteen of our patients had been infected prior to surgery, but soft-tissue healing had progressed to the point of operative suitability. In three of these notable postoperative complications developed. One graft, used in a compound fracture resulting from a missile wound, sequestrated and was later surgically removed. In one osteomyelitic cavity, previously covered with a well padded skin flap, drainage developed with subsequent sequestration of the graft. One chronically infected knee joint drained after the surgical arthrodesis, and the drainage was prolonged. However, fusion was eventually obtained and drainage finally ceased. In the 107 patients without infection before surgery, there were three instances of wound infection. In two of these, the spine had been fused; in neither did the infection extend deeply enough to require more than opening the wound. Both healed through secondary intention. One has definitely progressed to a good clinical result. The other has been followed seven months. He was listed in Chart III among the failures, as he had an unsatisfactory functional result. As seen by roentgenogram, the grafts appeared to be becoming incorporated. The third patient has been presented already; in him there was a failure of an arthrodesis (Chart VI). Wound breakdown developed after wrist fusion and metacarpal bone block. His original injury had consisted of

severe neuropathy, secondary to missile wounds. Postoperatively, severe circulatory disturbance developed, followed shortly afterward by wound breakdown.

Our records indicate that only one positive culture was obtained at the instant of implantation. In this patient, undergoing a spine fusion, exceptionally smooth convalescence and an excellent end result ensued.

The results in wound-healing observed in these patients in whom freeze-dried bone grafts had been used parallel the results normally expected for these various types of orthopaedic surgery. The authors are of the opinion that the wound infections with skin slough were probably due to contamination from other sources in two instances and to inadequate circulation in the third of the preoperatively uninfected cases.

SUMMARY AND CONCLUSIONS

In the past four years, 125 freeze-dried homogenous bone-grafting procedures have been performed. In ninety-nine patients there was an adequate follow-up; there were eighty-four surgical successes and fifteen surgical failures. Upon analysis, six were listed as technical failures, and nine (9.2 per cent.) were classed as graft failures.

The authors now use freeze-dried bone grafts regularly. The technique avoids additional incisions; the operative time is shortened; and select grafting material—either cancellous or cortical—is abundantly available.

Experimental evidence that freeze-dried homogenous bone grafts heal at a slower rate than do autogenous grafts has not been clinically appreciable thus far. There is no clinical evidence of untoward immunological response.

Central control, bacteriological standardization, long-term storage at room temperatures, and ease of shipment are significant advantages in the light of the needs of military surgery. The process can be advantageously used in large-scale cooperative civilian ventures.

The freeze-drying process has the disadvantage of high initial cost in equipment, time, and technical personnel. The process is not practical for adoption by the average hospital.

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DISCUSSION

Dr. Philip D. Wilson, New York, N. Y.: I had the pleasure in the early days of the Tissue Bank at Bethesda to visit it and to be shown what was being done.

I have been interested in this bank because of my interest in the bone bank, and I have studied the various presentations which had come from the Navy previously concerning this experimental work. This paper is the first clinical review of their study.

I think the reason for the Tissue Bank should be stressed. The Medical Departments of the Military Forces need to have a central laboratory in which bone-grafting material can be prepared under sterile conditions and from which it can be shipped at room temperature without deterioration. The freeze-drying method meets these requirements. Furthermore, methods have been developed whereby grafts can be procured from the cadaver under rigidly sterile conditions. Thus a great abundance and variety of bone is made available for grafting.

We believe, from our own experience with the use of bank bone, that the conclusions drawn by Dr. Abbott and his group [a] concerning the advantages of cancellous bone over cortical bone in the rapidity of healing apply to the use of these preserved grafts. Obviously, there is a great advantage in being able to have access to a sufficient quantity of any type of bone.

It is difficult to evaluate results from a clinical study. Because bone-bank grafts are used in so many different operations as supplementary material, the success of the operation depends not entirely upon the graft but upon other factors as well.

I think that the figures on the results of the use of freeze-dried bone in this series of ninety-nine cases are excellent. I do not think any of us could ask for better than 91 per cent. success; in our own series of over 400 cases, there were failures in 15 per cent. I suspect, when some of these cases have had a longer follow-up and a greater number have been studied, that their percentage of successes will be lower. Some of the cases must be followed for a much longer period than they have been before the evaluation of final results can be made.

When it comes to the question of the best bone-grafting material, I think autogenous bone is superior. Wherein lies this superiority? We have done a lot of experiments on animals and have found it very difficult to show any appreciable difference between healing with homogenous bone grafts and with autogenous bone grafts—even when gaps have been bridged. However, this is not true in human patients. I have been impressed with the fact that, in many of our patients in whom preserved homogenous bone grafts have been used, there is complete absorption of the graft. We have had to re-operate on some of these patients and have found absolutely no trace of the original graft. This occurs in a small percentage of patients, but, nevertheless, it does occur. In other patients in whom similar grafts have been used, complete healing has occurred. We are trying to find out why in some instances homogenous bone grafts behave in one manner and in others they behave differently. What is the explanation? Can it be foreign proteins or something else? The French and Belgians are making use at present of preserved bovine foetal bone which, I believe, is preserved by the freeze-drying method. They claim excellent results; and yet, from my own knowledge and experience, I cannot believe that those results are superior to results from the use of human bone.

When we use homogenous bone grafts, we should insert them so that they are in apposition with host bone throughout their entire extent. When we bridge a gap in bone, the chances of failure will be greater if homogenous bone has been used than if autogenous bone has been used. As Watson-Jones said, some years ago when he was here, "When I use a bone graft, I want bone that is going to fight for me". We have made an investigation of the blood types of the bone we have used; we have had about seventeen patients with different types of incompatibility between the donor bone and the host bone. We have had the most extraordinary findings. Some of the grafts that were completely incompatible as far as the blood type of the host was concerned healed very well. Others which were compatible failed. I do not think we can, therefore, blame that particular factor. There are other factors which we have not yet discovered. The answer will be found in further study and more research.

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Dr. Robert D. Ray, Seattle, Washington: Capt. Carr and Lt. Cmdr. Hyatt have demonstrated in an excellent clinical study that freeze-dried bone can be used successfully in a variety of grafting procedures. Such a clinical study raises many provocative questions. Freeze-dried grafts are probably dead, and undergo replacement by the tissues of the host. Does this process of replacement depend on the organic matrix, on the products of cellular necrosis, on the inorganic salts of the graft, or on a combination of these factors?

If the organic matrix is the important component, does it act as an inert "trellis", as an "inductor" for new-bone formation, as an "osteogenic stimulus" (a term used by the authors) or, possibly, as a foreign protein giving rise to a homogenous-tissue reaction?

With regard to the inorganic salts, experimental evidence suggests that synthetic hydroxyapatite crystals can act as a trellis for new-bone formation [a]. However, we do not yet know whether the crystals play a passive role in this process or whether they furnish a local source of calcium or phosphate for the matrix of the newly formed bone. The crystals do not "induce" bone formation in the soft tissue. They are not so effective as autogenous grafts of fresh bone are in repairing bone defects.

It is possible, of course, to fashion autogenous grafts in which the cellular elements play a minor role in the subsequent fate of the grafts; but grafts can also be fashioned which will produce bone, not only in the body, but also in tissue culture. So far as we have been able to determine in our laboratory, this cannot be said for freeze-dried materials. (This does *not* imply that dead or inert grafting materials do not have a useful place in orthopaedic surgery, but only that their limitations should be recognized.) Survival of transplanted cells depends, among other factors, on the "density" of the bone, its thickness, and the vascularity of the recipient site. Viable bone cells can be preserved for prolonged periods at low temperatures if the graft has been dehydrated first and then has been slowly frozen [b].

(*Continued on page 596*)

ISOLATED PARALYSIS OF THE SERRATUS ANTERIOR MUSCLE

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INTRODUCTION

Isolated paralysis of the serratus anterior is an entity that should be more widely understood. Early recognition, followed by treatment that is comparatively simple, although prolonged, usually leads to a satisfactory outcome. The purpose of this paper is to present information pertaining to the clinical picture, anatomy, etiology, and treatment of the condition and to discuss our experience with twenty cases.

Less than 250 cases of isolated paralysis of the serratus anterior have been presented in the literature since Velpeau's first report in 1837. Only two series of more than seven cases have been collected[3, 7]. Fully thirty methods of treatment, many of them surgical, have been advocated. Prognosis has varied from very good to very poor. The explanations of the etiology have differed widely. The sole aspect that many descriptions have in common is the clinical picture.

CLINICAL PICTURE

Paralysis of the serratus anterior may come on immediately after a hard blow or after a chronic strain of the neck and shoulder regions. Frequently it may appear insidiously and sometimes even painlessly. In general, however, there is first noted an aching or "burning" discomfort of varying degrees of severity in the neck and shoulder, localized vaguely in the region of the scaleni. The pain may radiate down the arm or around toward the scapular area. This is followed, perhaps a day or two later, by inability to raise the arm properly and by winging of the scapula. After the weakness has been well established, the patient complains of a fleeting ache relieved by rest, inability to elevate the arm satisfactorily, and rapid tiring, as well as the deforming effect of a winged scapula.

The fully developed case of paralysis of the serratus anterior shows the classical picture of posterior winging of the scapula. This is usually accompanied by an inability to abduct the arm beyond 90 degrees (Fig. 2-A). During attempts to do push-up exercises or efforts to perform other exercises which require strong anterior scapular fixation to the chest wall, the winging becomes very marked. Generally the shoulder is displaced forward and droops to some extent. There is frequently secondary weakness of some protagonist muscles, particularly the inferior portion of the trapezius, often accompanied by a tightness, sometimes painful, of certain antagonist muscles such as the rhomboids and pectoralis minor.

ANATOMICAL CONSIDERATIONS

The syndrome is well explained by the anatomy of the long thoracic nerve and its relationship to the serratus anterior. The long thoracic nerve or external respiratory nerve of Bell is almost unique in that it arises directly from the spinal nerve roots, carries no known sensory fibers, and goes to a single muscle of which it is the sole innervation of consequence. It originates from the anterior branches of the fifth, sixth, and seventh cervical roots, except for a few minor variations of this pattern described by Horwitz and Tocantins[4]. The upper two branches of origin pass through the scalenus medius and unite with the third branch just below this point. The nerve then descends under the brachial plexus and down the anterolateral aspect of the chest wall, giving off on its way branches to the serratus digitations.

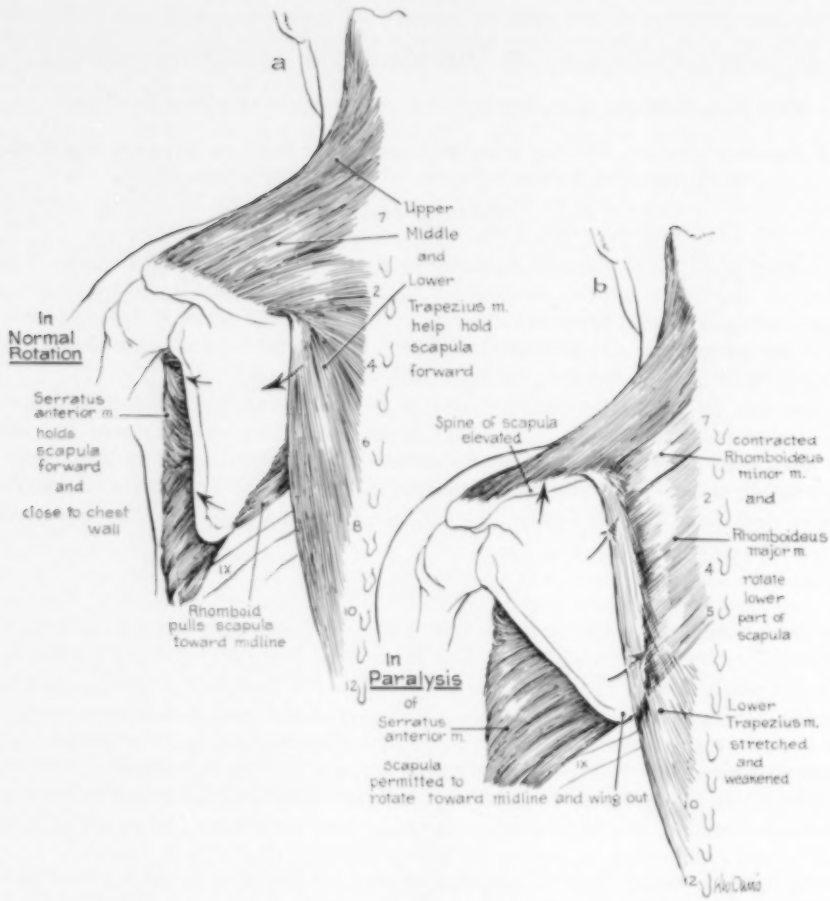

FIG. 1

Fig. 1, *a:* Normal position of the scapula at rest. *b:* In serratus weakness the scapula rotates backward and upward, stretching the lower fibers of the trapezius. The rhomboids are shortened and contracted.

The serratus anterior is broad and flat; it arises in the form of multiple digitations from the upper eight or nine ribs in the anterior axillary line, and attaches to the deep surface of the scapula along its vertebral border. Its primary function is to draw the scapula forward. This action causes the entire shoulder to be brought anteriorly by a movement at the sternoclavicular joint. The movement of stretching forward, as in fencing, is due to this action of the muscle. Furthermore, by its relation to the inferior angle of the scapula, the serratus anterior causes, along with the trapezius, a rotation of the scapula, which results in a tilting upward of the glenoid cavity, thus facilitating the upward movement of the arm above the head (Fig. 1, *a*).

ETIOLOGY

It is difficult to understand how a single muscle extending over such an extensive area and so well protected could be completely knocked out of action by direct trauma without considerable involvement of its neighbors. In an analogous situation, trauma or other irritation to any or all of the three nerve roots, or to the spinal cord, could hardly have such a selective action on only one particular nerve. Therefore, it is reasonable to

assume that the pathological condition underlying this lesion is located in the long thoracic nerve itself. The cause of this condition, however, is another and far more difficult matter to explain.

Some cases are indisputably traumatic in origin, beginning immediately after a severe blow, fall, or sudden malforming twist and strain which force the shoulder downward and backward. Others follow more sustained or chronic traumata, such as prolonged carrying of a heavy knapsack, arduous shoveling, strenuous games of tennis, and the like. The marked preponderance of cases occurring on the right side in this series, coupled with the 83 per cent. preponderance of those cases in the literature in which the side was ::oted, may be statistically significant and could provide some clue to the etiology. In a number of cases the condition developed gradually several days or more after operative or obstetrical procedures, perhaps because of cramped positions of physical strain while the patient was under the relaxing effects of anaesthesia. In others it has been reported as toxic in origin after certain infectious or viral diseases. In some it has even followed the injection of sera, vaccines, and the more common antibiotics and has been regarded as a sequel to an allergic reaction.

Of 111 cases reported since 1925, thirty-five were attributed to acute trauma, sixteen to recurrent trauma, thirteen to postinfectious conditions, eight to injections, six to postpartum and seven to postoperative complications. Thirteen were of unknown etiology. In addition, Hansson ascribed thirteen cases to exposure to cold. These diverse predisposing factors are very similar to those held responsible for the development of Bell's facial palsy and other single nerve palsies such as those of the radial, peroneal, and axillary nerves. This fact, combined with the similarity of the clinical pictures, recovery patterns, and anatomical relationships, seems to indicate a common pathological picture of nerve trauma or non-specific "neuritis" which links these varied isolated paralyses with isolated paralysis of the serratus anterior.

EXAMINATION

The value of a careful muscle examination can hardly be overemphasized, not only in arriving at a proper diagnosis, but in differentiating isolated paralysis of the serratus anterior from other conditions which may resemble it superficially. The clinical picture has already been touched upon. Since the most striking feature is winging of the scapula, tests must be made to evaluate the integrity of the serratus anterior and its power to abduct the scapula, to rotate its inferior angle forward against the chest wall and, secondarily, to assist in raising the arm. The simplest method of testing this muscle is to have the patient standing and facing a wall. The arms are outstretched and the palms of the hands are placed against the wall at shoulder level, or slightly above, with the elbows straight, and are pushed hard against the wall. If the muscle is paralyzed, the winging of the scapula will be instantly apparent. There are other confirmatory tests, made with the patient supine and sitting, as described by Kendall and Kendall.

DIFFERENTIAL DIAGNOSIS

Differentiating isolated serratus anterior palsy from other conditions requires the taking of a detailed history, and a careful muscle check of at least the whole shoulder girdle. Careful examination with an understanding of the pathology of this entity will eliminate neurological disease which has attacked the cord or nerve roots, because in such conditions other weaknesses and neurological changes will be found which conform to characteristic anatomical patterns. Generalized involvements, such as anterior poliomyelitis, combined sclerosis, the dystrophiae and atrophiae, will present spotty or more extensive weaknesses not compatible with secondary adaptation to involvement of a single nerve and a single muscle. A number of the patients herewith presented were referred with erroneous diagnoses ranging from subacromial bursitis to Guillain-Barré syndrome. One

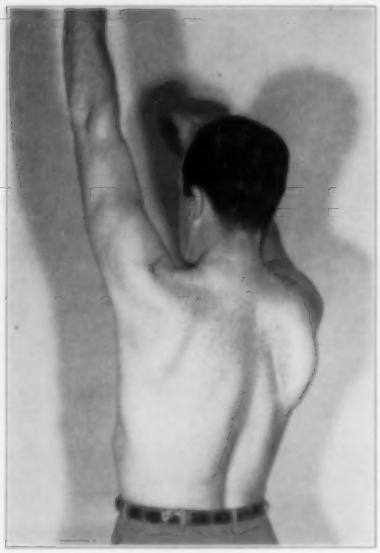

FIG. 2-A

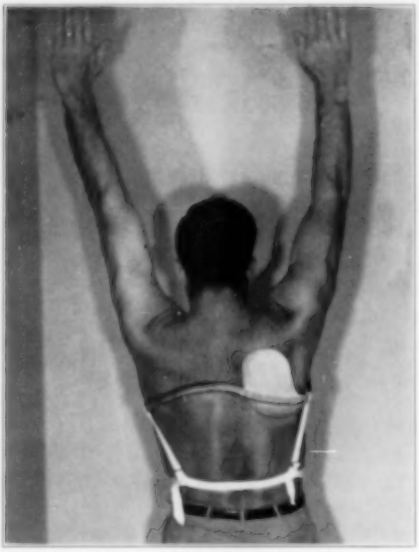

FIG. 2-B

Fig. 2-A: Paralysis of the serratus anterior on the right. Note the winging and rotation of the scapula. There is inability to abduct the scapula and hence inability to abduct the arm.

Fig. 2-B: The brace holds the lower portion of the scapula in forward rotation and abduction and presses it against the chest wall to limit winging; almost complete abduction of the arm is possible.

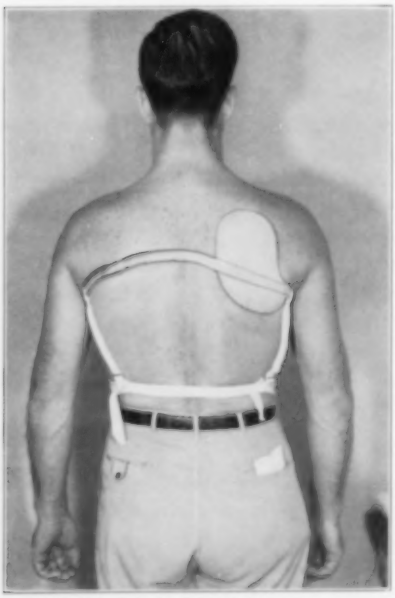

FIG. 2-C

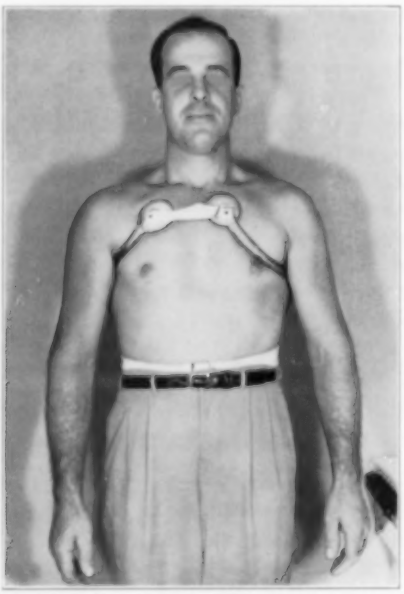

FIG. 2-D

Fig. 2-C: Photograph showing the brace in a position of rest. The cup fits snugly over the lower two thirds of the scapula, holding it in a position of abduction and preventing drooping of the shoulder or chronic stretch of the serratus anterior.

Fig. 2-D: View of the brace from the front. By counterpressure against the chest wall, the padded disks give firm stabilization of the scapular cup posteriorly.

patient had had a scaleniotomy and a cervical laminectomy. One of our own cases was at first believed to be unrecognized poliomyelitis, because of the associated weakness of a stretched lower segment of the trapezius. Another patient, on the other hand, was originally considered to have a bilateral serratus anterior syndrome until a more careful muscle check revealed the lesion to be an early muscular dystrophy of the scapulohumeral type.

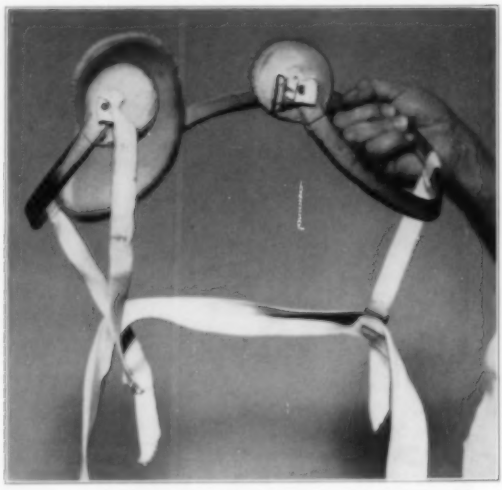

FIG. 3

The brace itself weighs little over a pound. It is made of tempered, slightly springy brace steel, three-sixteenths of an inch thick and five-eighths of an inch wide. The padded steel cup and the disks are covered by leather. The cup is fitted to the individual scapula, with the patient's arm lying in full passive abduction.

TREATMENT

As has been stated, fully thirty methods of treatment, many of them surgical, have been recommended. When the diagnosis has been made and the anatomy of the condition is understood, treatment should follow rational lines. The long thoracic nerve will recover spontaneously in the great majority of cases in from three to six months. Therefore, during this period, therapy should be directed toward guarding the serratus anterior and its protagonists from overstretching, and toward strengthening these muscles as rapidly as possible. Similarly the contracted and often painful antagonist muscles should be stretched to prevent scapular fixation in the abnormal position.

The use of a shoulder spica, as advocated by Berkheiser and Shapiro, or the elevation and derotation brace method as described by Horwitz and Tocantins are sound procedures but rather severe, as they incapacitate the patient for a number of months. The scapular cup devised by Wolf and used by us in several cases seemed theoretically to be the best ambulatory treatment, as it allowed freedom of both arms. However, we found this brace quite difficult to fit satisfactorily and many patients would not tolerate it. After a number of alterations, a brace has been evolved (Figs. 2-B, 2-C, 2-D, and 3) which is light, comfortable, and gives better scapular support than any we have previously used. Its main virtue is that the patients like it and will wear it constantly. With it they can lead a normal life, provided that heavy use of the affected arm is not required, yet they seem to get as good support as from a shoulder spica and the results are as good. Its use is also recommended in other conditions, such as poliomyelitis, in which serratus anterior weakness is a major factor.

Before this brace was perfected we used a reinforced canvas shoulder brace (Fig. 4) in some of the cases with milder involvement; we still recommend its use for the later stages of the condition when tests of the serratus show only slight weakness. This canvas brace partially limits the winging and rotation of the scapula, but obviously cannot prevent the adduction in cases in which the serratus anterior has been severely weakened.

The indications for operation seem meager in a condition in which there is such a relatively good prognosis on a conservative regimen. Some of the cases reported in the literature in which operation was performed seem to have been inadequately or impatiently treated. The fact that several of our patients were seen a year after the onset of symptoms indicates that failure to provide protection will frequently prevent recovery, while institution of protection will promote recovery even at a late date. Many of the good

FIG. 4

Fig. 4: Photograph of the canvas shoulder brace. Heavy steel stays on each side of the back and tight straps across the chest hold the scapula next to the chest wall. The buckle on top of the shoulder can be tightened and tends to derotate the scapula. Adduction of the scapula is not prevented.

FIG. 5

Fig. 5: Photograph of a patient with serratus anterior palsy but with strong lower trapezius fibers which prevent backward rotation of the lower border of the scapula on abduction and allow full movement. (Reproduced by permission from *Muscles, Testing and Function*, by Henry O. Kendall and Florence P. Kendall, p. 127. Baltimore, The Williams and Wilkins Co., 1949.)

results attributed to operations, such as fascial fixation or muscle transplantations, have been due, it is believed, to the mere reinforcing of a muscle the function of which was already returning. On the other hand, operations seem indicated when there is proved irreparable damage to the long thoracic nerve, when a thorough and adequate conservative course of treatment has failed, or sometimes when the serratus anterior palsy is part of another disease, such as poliomyelitis.

Enthusiasm for conservative treatment is not to be understood as a condoning of inadequate treatment. Admittedly the course of therapy is long and arduous and requires specialized care. Although only one muscle is originally and primarily involved, there is produced a definite effect upon its antagonists and protagonists. Antagonists, such as the rhomboids, relieved of the duty of balancing the normal serratus pull, become contracted and excessively strong. The trapezius, especially its lower and middle thirds, although a competitor as an adductor, is an assistant in the complex rotatory control of the scapula (Fig. 1) and tends to become stretched and weakened. However, it is possible to strengthen the trapezius sufficiently to resist this stretch (Fig. 5) and even to compensate partly for a weak serratus anterior in obtaining full abduction. This strengthening of the lower fibers of the trapezius is one of the major aims in therapy and does much to minimize the continuous elongation of the serratus anterior which so delays its recovery. Patients are cautioned to forego any strenuous activity which abuses the weakened structures. Careful stretching of contracted and often painful antagonist muscles, such as the rhomboids and the pectoralis minor, completes the plan of treatment.

The outline of treatment here presented is a combination of physical therapy and brace protection, which has proved satisfactory in our more recent cases.

OUTLINE OF TREATMENT

For complete paralysis of the serratus anterior: The brace should be worn day and night. Exercises should consist of muscle-setting, exercising the serratus anterior in its function as a rotator of the scapula: With the patient supine, the arm is placed overhead, resting on a pillow, and the patient is asked to press the arm down on the pillow (in the direction of completing arm-raising overhead). He should be made aware of trying to bring the inferior angle of the scapula forward during this movement and may be encouraged to palpate the serratus anterior with his opposite hand during this exercise. Although abduction of the scapula is a function of the serratus anterior, exercises involving abduction of the scapula are avoided because of the frequency of associated trapezius weakness.

For moderate weakness of the serratus anterior: The brace should be worn during the day, but not necessarily at night. Exercise: With the patient supine, the therapist flexes the arm slightly beyond 90 degrees; the patient is instructed to continue to elevate the arm and at the same time press it toward the table against slight resistance. The amount of resistance should be dependent upon the ability of the patient to bring the inferior angle of the scapula forward in the normal rotation action of the serratus anterior. This exercise also helps to strengthen the lower fibers of the trapezius. (If the scapula rotates backward instead of forward, the resistance is too great.)

For slight weakness of the serratus anterior: Weakness may be considered slight when the patient is able to raise the weight of the arm in movements requiring scapular fixation, but is unable to take resistance or to lift any additional weight. The canvas brace or the metal brace should be worn during any activity which requires lifting a weight with the affected arm. Exercises should be begun in a sitting or standing position, the weight of the extended arm being raised forward in flexion and sideways in abduction through full range to complete overhead extension.

For tightness of shoulder adductors: With the inability to raise the arm through a full range of motion, the problem of adaptive shortening of the shoulder adductors may be encountered. If examination reveals a limitation of motion in passive raising of the arm overhead, treatment should be directed toward maintaining normal length of these muscles. Heat and massage should be applied to the shoulder adductors. Passive stretching of the arm in overhead extension should be done by the therapist to avoid strain on the weak serratus anterior, and it is preferable that the patient be supine on the treatment table in order to keep the scapula braced against the table and to avoid winging of the scapula.

For tightness of the rhomboids: The rhomboids, being direct opponents of the serratus anterior, tend to shorten. There may be pain in this region, associated with the muscle tightness. Heat and massage should be applied to the rhomboids. The arm should be raised passively overhead while pressure is applied along the vertebral border of the scapula, bringing the inferior angle of the scapula through the normal range of rotation.

MATERIAL AND RESULTS

Twenty cases of isolated paralysis of the serratus anterior are herewith presented and analyzed. Of these, seventeen have had the benefit of complete examination of the muscles of the involved shoulder girdles and arms and twelve have had repeated muscle examinations. The right side was involved in eighteen cases, the left side in two cases. The ages of the patients ranged from nine to fifty years, the average being 32.7 years. The sex distribution was evenly divided. The duration of symptoms at the first visit was from one week to one year, the average being seventeen weeks. The etiology, in so far as it could be determined, was recorded as follows: acute trauma, two; chronic trauma, five; postpartum complication, one; postinfectious complication (generally diagnosed as "virus"), three; postinjection complication, four (tetanus antitoxin, two; penicillin two); and no known cause, five.

Strength of the serratus anterior at the first visit ranged from 0 to 30 per cent.,

with an average of 10 per cent.; at the third month, it was from 45 to 60 per cent., with an average of 50 per cent., in eight recorded cases; at the sixth month, strength of the serratus anterior was from 70 to 100 per cent., with an average of 85 per cent., in ten recorded cases. In seven cases, follow-up was incomplete or the lesion was too recent for evaluation.

The associated trapezius strength was as follows: upper trapezius fibers, average 100 per cent.; middle and lower trapezius fibers, average 65 per cent.

Associated rhomboid and pectoral tightness was noted in thirteen cases and was not mentioned in seven.

Treatment was by the scapular cup type of brace in eleven, by canvas shoulder brace in six, and by physical therapy and sling alone in three.

At six months the relation of treatment to the end results could be evaluated as follows: In six patients treated with the scapular cup type of brace, the average serratus anterior power was 90 per cent.; in two patients treated with the canvas brace, the average serratus anterior power was 80 per cent.; and in two patients treated by physical therapy alone, the average serratus anterior power was 85 per cent.

NOTE: The authors wish to acknowledge with gratitude the technical assistance of Mr. Walter Wolfing in the construction of the scapular cup type of brace.

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FEMORAL SHORTENING BY "OBLIQUE-STEP" OSTEOTOMY AND INTRAMEDULLARY FIXATION

BY KENNETH G. JONES, M.D., LITTLE ROCK, ARKANSAS

Perhaps no other surgical procedure recently made popular by its attributes has contributed so much to the well-being of the orthopaedic patient as intramedullary fixation of the fractured femur. The economic savings gained by this method of treatment are tremendous. Results have, in most instances, been gratifying. Thus, it seems only logical that such a satisfactory means of handling fractured femora could be adapted to femoral-shortening operations where equalization of limb length is desired.

Thompson and his colleagues reported a series of cases of femoral shortening; in eleven cases, the shortening was accomplished by transverse osteotomy with Küntscher-nail fixation. They recommend that this technique not be used because of the unusually large number of operative and postoperative complications which were encountered.

The present author has found that, with only a slight modification of the usual nailing technique, the Hansen-Street medullary nail can be used to advantage in femoral shortening. The only special consideration required for this operation, in addition to the usual good femoral-nailing practices, is the cutting of the "oblique step" which prevents distraction of the osteotomized bone once the nail has been driven across the osteotomy. This simple mortising cut is described and illustrated herein. In one of the two cases to be presented, the patient experienced an operative complication which was recognized and readily corrected on the table.

TECHNIQUE

After the desired length of bone to be removed has been determined, either by clinical measurement or spot scanograms, the patient is placed in the supine position on the operating table and tilted approximately 30 degrees away from the side to be operated upon. With the limb draped free, the anterior surface of the mid-shaft of the femur is approached through Henry's anterior lateral incision of the thigh. The vastus intermedius is split longitudinally and reflected subperiosteally from the front of the femoral shaft for a sufficient distance to permit removal of that amount of bone to effect the desired shortening. With a sharp osteotome, the pattern of the oblique-step osteotomy is laid out on the anterior surface of the femur; drill holes are made along the pattern from front to back through both cortices; the drill holes are connected by an osteotome; and the excess bone is removed. The cut edges of the bone are trimmed, if necessary, in order that, when overlapped, the proximal and distal steps will fit accurately together according to the pattern.

The Hansen-Street nail has been used in the two cases under consideration. After the correct length of the nail has been determined, the nail is inserted up through the medullary canal of the proximal femoral fragment and out through the skin over the greater trochanter in the usual manner. The mortised oblique steps are fitted together to restore the normal femoral contour and are held by a bone clamp; then the nail is driven into the distal femoral fragment. The oblique-step osteotomy is securely locked; thereby, stability is assured, distraction is prevented, and ideal apposition of the ends for bone healing is provided. The wound is closed in layers. No external support is needed.

The bone-section pattern (Fig. 1) is laid out on the front of the femur in an oblique-step design. One and one-quarter inches is considered ideal for the height of the oblique bone step. If this is the length of femur to be removed, the pattern will appear, when laid out on the front of the femur, as in Figure 1, *a*, with the shaded area being removed; this bone may be discarded or it may be used as a bone graft, as in Case 2. It should be observed

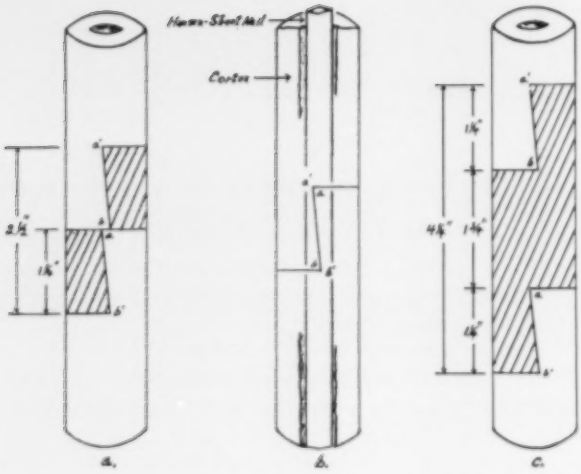

FIG. 1

The "oblique-step" osteotomy as laid out on the front of the femur through Henry's anterior lateral incision.

that both the proximal and distal steps slant across the longitudinal axis of the bone from their respective bases, thus creating overhangs which are the key to the locking and the prevention of distraction as well as of axial rotation, after the nail has been driven across the osteotomy lines (Fig. 1, *b*). If more than one and one-quarter inches of bone is to be removed, the distance between the ends of the proximal and distal steps is increased by an amount equal to the total desired shortening less one and one-quarter inches, and a similar pattern is laid out. Figure 1, *c*, shows the pattern as it would be drawn on the femur if the bone were to be shortened three inches. After removal of the bone and insertion of the nail, the picture would be the same as in Figure 1, *b*.

CASE 1. G. M., a white male, twenty years of age, was of normal stature until, at thirteen years of age, he suffered a simple fracture of the right femur. Union did not take place until four years later. During the interim, the patient had had an open reduction with plate fixation; later, the plate was removed because of distraction and infection; and the patient had worn several hip spicas and two walking caliper-type braces. While function of the right lower extremity was good, once healing had been completed, the injured right femur was two inches shorter than the left, and the growth of the right tibia had been retarded one inch. Examination revealed a marked pelvic tilt to the right side. The left lower extremity was normal in all respects. The patient had partially compensated for this disability by wearing a two and one-half inch shoe elevation on the short side. When first seen by the author, he was desirous of surgical correction of his three-inch limb-length discrepancy.

On June 2, 1953, the patient was admitted to St. Vincent's Infirmary where spot scanograms corroborated clinical measurements. These roentgenograms disclosed one inch of shortening of the right tibia and two and one-eighth inches of shortening of the right femur, making a total of three and one-eighth inches of actual shortening. To completely equalize the limb lengths, it would be necessary to shorten the left femur by three and one-eighth inches, in which event the left knee joint would be one inch above the right knee joint, or to perform shortening osteotomies of both the left tibia and the left femur. In order to limit surgical intervention to one procedure, it was elected to shorten the left femur two and one-half inches. This plan of treatment would position the left knee joint three-eighths of an inch above the contralateral knee joint, and the shortening of the right lower extremity would be compensated to within five-eighths of an inch of the left. This slight discrepancy could easily be accommodated by pelvic tilt and a heel wedge of three-eighths of an inch on the right side.

On June 9, 1953, two and one-half inches of the left femur was removed, and the oblique-step osteotomy was locked by the technique described earlier. A check roentgenogram made of the knee joint while the patient was still on the operating table revealed that the nail was slightly long and that it had entered the knee joint, displacing a fragment from the lower end of the femur, as usually happens when a nail enters the knee joint. An arthrotomy through a small incision was performed for removal of the displaced fragment. The nail was retracted approximately one centimeter. All wounds were closed; no external support was needed.

Postoperatively, the patient's course was uneventful. Roentgenograms (Fig. 2-A) made on June 15, 1953, revealed excellent alignment of the femur without any tendency for distraction. All sutures were removed on the tenth postoperative day. Atrophy or shrinkage of the excess muscle mass of the left thigh was apparent by this time. Active and passive exercises were instituted. The patient was discharged on

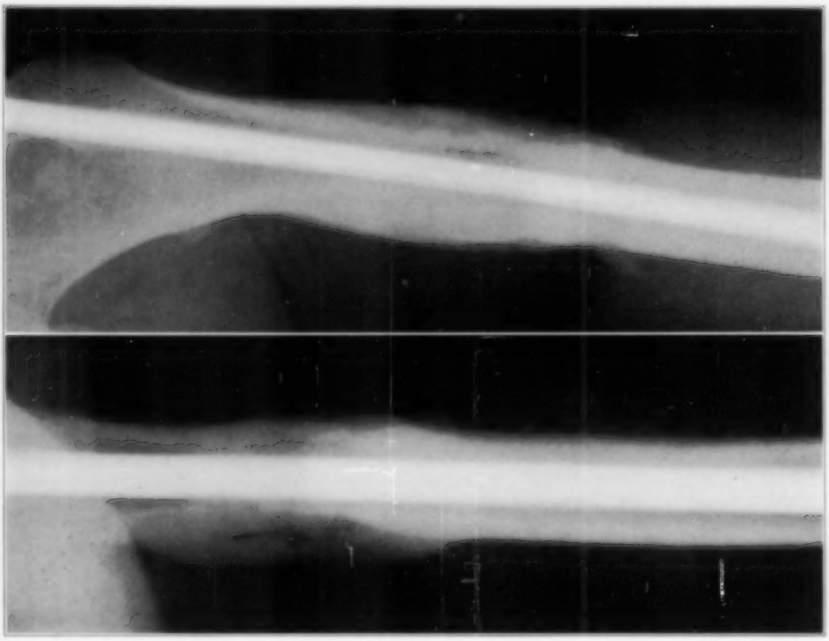

Fig. 2-B
June 11, 1954

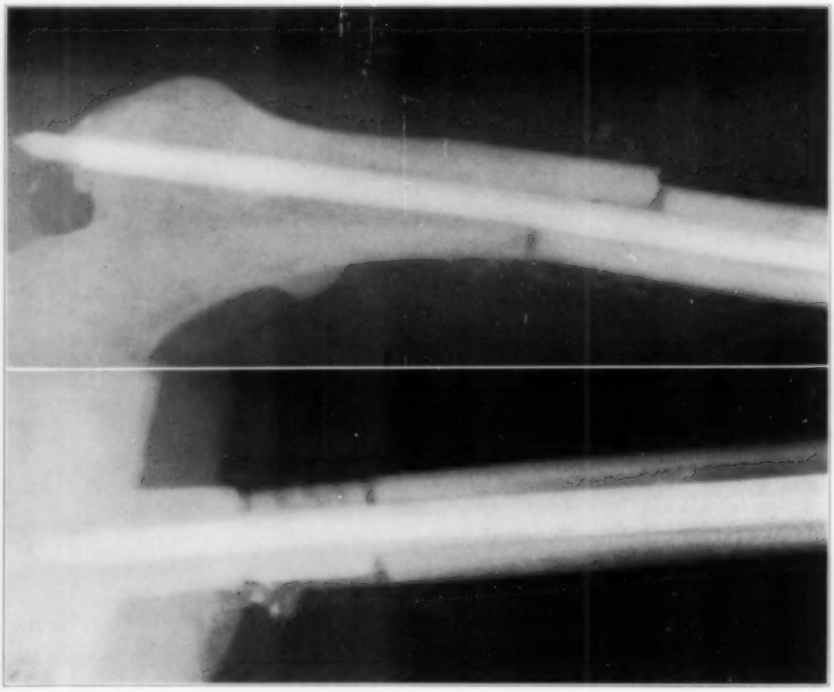

Fig. 2-A
June 15, 1953

crutches on June 27, 1953. When evaluated in the Crippled Children's Division Clinic on August 13, 1953, he was still walking with crutches, but bearing approximately 50 per cent. of his weight on the left lower extremity. There was a complete range of painless motion of the left knee joint with good power in the quadriceps and hamstrings.

On August 17, 1953, the patient was in an automobile accident, as a result of which he sustained extensive soft-tissue damage to the right forearm which required multiple skin grafts. However, even though the intramedullary pin had been inserted only two months and eight days earlier, the shortened femur was not injured.

On June 11, 1954 (twelve months postoperatively), the patient returned for a follow-up evaluation. At this time, the examination revealed the right leg to be still clinically shorter than the left leg by one-half inch. He stated, however, that he did not feel the need for a shoe lift on the right side to compensate for the slight uncorrected shortening. The left lower extremity measured thirty-three and one-half inches as compared to thirty-three inches for the right. The patient's height is five feet and seven inches. The left thigh measured twenty-nine inches in circumference, while on the right side at a comparable level the circumferential measurement was found to be twenty-six and one-half inches. The contours of the extremities were nearly normal. The patient walked without a limp. He did not experience pain about the proximal end of the femoral nail. Knee motion, both active and passive, was complete and painless. The patient was entirely satisfied with the result obtained. Roentgenograms (Fig. 2-B) made at the time of that visit revealed a solid union at the site of the osteotomy.

Case 2. C. H., a white male, seventeen years old, had contracted poliomyelitis at the age of seven. Residual involvement was restricted to the right lower extremity. After examination of the patient, the following four procedures were recommended to be performed in this order:

1. A triple arthrodesis on the right side, to correct the calcaneocavus deformity and to overcome the lateral instability of the foot;

2. Femoral shortening on the left side, to correct the limb-length discrepancy of one and three-eighths inches;

3. Transplantation on the right side of the tibialis posterior and peronaei into the weak calf group; and

4. Also on the right, a Jones suspension to correct the cock-up of the great toe.

The first procedure with the insertion of staples was performed at St. Vincent's Infirmary on October 15, 1953. On November 24, 1953, the left femur was shortened one and one-quarter inches, by the technique described, so that the pelvis was almost completely level. Only five-eighths of an inch of the discrepancy was in the right femur, and, as a result of the removal of one and one-quarter inches of bone from the left femur, the left knee joint was elevated five-eighths of an inch above the right knee joint. One fragment of the resected bone, with muscle still attached, was laid along the osteotomy site as a graft. Healing of the soft tissues was uneventful except for an effusion of 40 cubic centimeters of straw-colored fluid into the left knee joint postoperatively. After one aspiration, the joint swelling did not recur. Roentgenograms (Fig. 3-A) made on January 11, 1954, revealed that the position of the osteotomy was being maintained and that callus was forming in a normal manner. On January 12, 1954, the third operation was performed. By February 9, 1954, it was found that there was a complete range of painless motion in the left knee joint; muscle power of the thigh was very good; and the patient had just begun to ambulate without the assistance of crutches. The left lower extremity was stable.

On October 22, 1954 (eleven months postoperatively), he returned for a follow-up examination: by this time satisfactory function of the twice-operated-upon right foot was evident. The foot was well aligned with only a barely perceptible limp, due to some slight residual non-compensable weakness of its calf group. The patient is satisfied with the right foot as it is now, and he does not feel the need for the Jones suspension. There was no evidence of weakness, pain, or a limp on the shortened left side. The osteotomy was clinically solid. Limb lengths were found to be thirty-two and five-eighths inches on the left and thirty-two and one-half inches on the right. On the left side, joint motion, both active and passive, was complete and painless, while muscle power was normal throughout the extremity. There was no tenderness about the proximal end of the intramedullary nail. The patient was satisfied. Roentgenograms made on October 24, 1954 (Fig. 3-B), revealed solid bony union of the shortened femur.

CONCLUSIONS

1. Secure internal fixation can be provided by the Hansen-Street intramedullary nail alone after femoral shortening if the oblique-step osteotomy is used.

2. Normal function of the extremity can be restored more certainly and at an earlier date by the technique described than may be expected from other methods of femoral shortening.

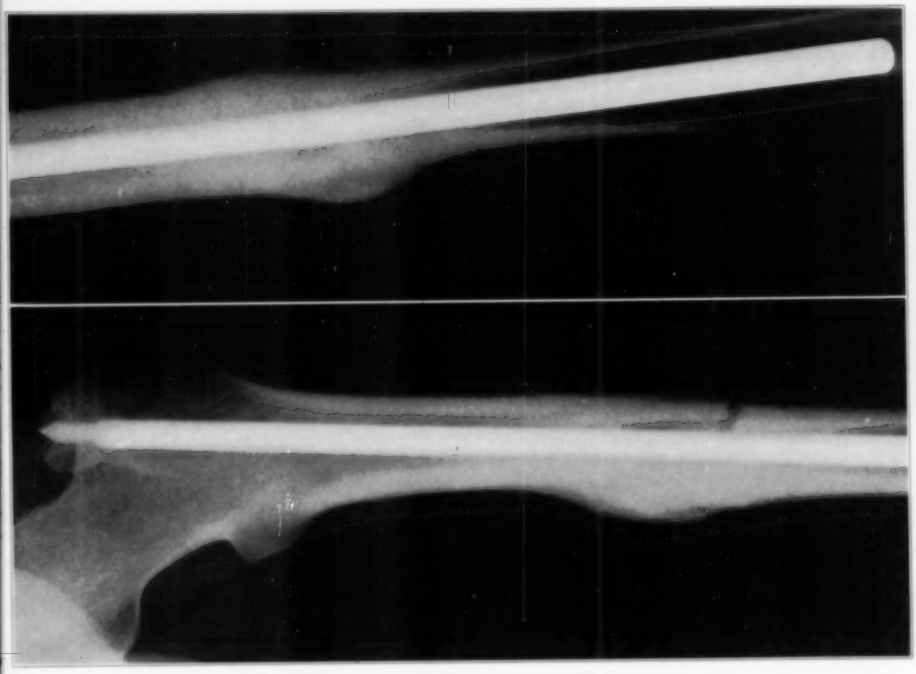

Fig. 3-B
October 24, 1954

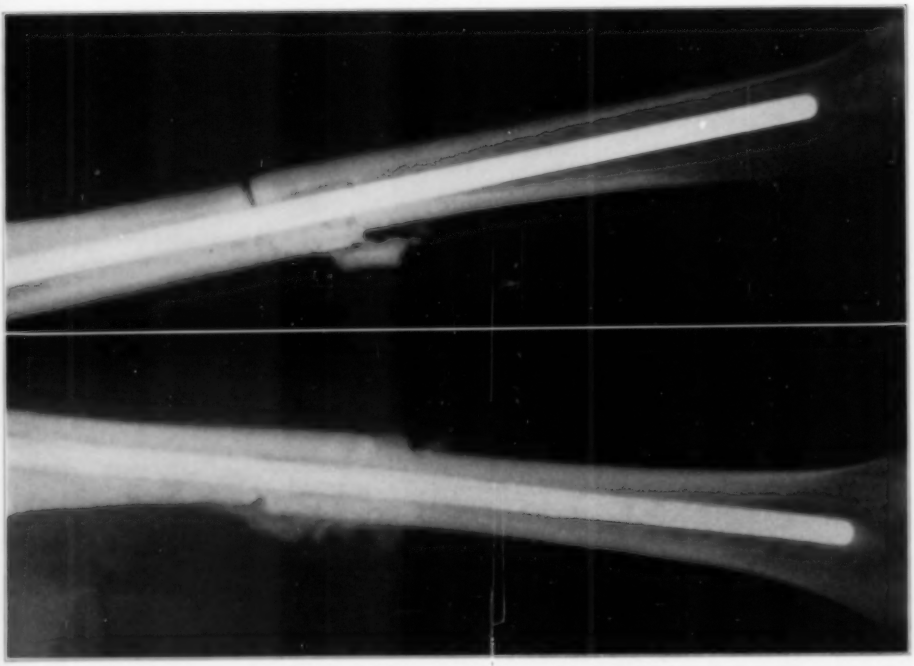

Fig. 3-A
January 11, 1954

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OSTEOMYELITIS OF THE SPINE DUE TO *SALMONELLA CHOLERAE SUIS*

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Salmonella infection in man has been reported with increasing frequency since Salmon and Smith first isolated the organism which they believed to be the cause of hog cholera. Seligmann and his associates[14,15], in reporting on 2,916 cultures from human sources from the Salmonella Center at Beth Israel Hospital in New York, recognized fifty-three different Salmonella types. Including those reported from other countries, about 200 different types are now recognized [21]. In the series of cultures reported by Seligmann and his associates[14,15], *Salmonella typhi murium* was the organism most frequently isolated. This was also the organism most commonly found in the group of cases reported by Bornstein, Saphra, and Strauss.

Osteomyelitis due to *Salmonella cholerae suis*, as well as to other members of the Salmonella group, has been reported. Harvey reported seventy-one patients with infection due to *Salmonella cholerae suis*. Of this number, fifteen had involvement of the bones or joints severe enough to demand clinical attention. In all of the fatal cases, multiple involvement of the skeletal system was recorded. Weaver and Sherwood reported one case of osteomyelitis in a child. Kuttner and Zepp reported one case with bone involvement. Gajzágó and Göttche reported one case of osteomyelitis. Goulder and his associates reported that the skeletal system is involved in 20 per cent. of the cases of *Salmonella cholerae suis* infection in man. The most frequent sites of skeletal involvement seem to be the proximal end of the humerus, the distal end of the femur, and the distal end of the tibia.

We have been unable to find any recorded case of osteomyelitis of the spine due to this organism*, although there would seem to be no reason why this site should be spared. Guri, Smith, and Kulowski do not list this as a causative organism in their series of cases of osteomyelitis of the spine. For this reason, the following case is of interest.

* Harvey [7] in his article includes the following sentence: "At the present time there is in this hospital a patient with Salmonella suipestifer infection of the spine, a child who is not included in the present report." However, no subsequent report of this case seems to be available in the literature.

CASE REPORT

V.M., a Negro male, twenty-eight years old, was admitted to the Orthopaedic Service of the Hospital of the University of Pennsylvania on September 12, 1951, complaining of acute low-back pain on the right side. He had been well until three days before admission, when he awoke with a dull pain in his low back. In his work as a plasterer he had had no injury, although a year earlier he had some low-back pain which was attributed to a lifting type of strain. The pain became worse during the day of onset and on the following day he went to his local physician, who strapped his back and gave him an injection of penicillin. The next day, he was seen again by his family doctor and admission to the Hospital was advised. He had had no chills but, on the day before admission, had taken his temperature, and found it to be 104 degrees. He had had no nausea, vomiting, or abdominal pain and had had no diarrhoea. There had been no urinary symptoms, no cough, and no hemoptysis.

Physical examination on admission revealed a well nourished young Negro male, in considerable pain, especially on any movement of the spine. Temperature was 102, pulse 72, respirations 20, blood pressure 105 systolic, 65 diastolic. General physical examination revealed nothing unusual; the lungs were clear, there was no tenderness over the abdomen, and no masses were palpable. Examination of the spine showed a point of acute tenderness along the right iliac crest just lateral to the posterior superior spine. There was no evidence of a mass or of fluctuation. There was no tenderness over the spinous processes. There was moderate guarding of the paravertebral muscles; both anteroposterior and lateral motions were limited to less than 25 per cent. of normal and any attempt at motion was quite painful. There was no tenderness to deep fist percussion along the spine; straight-leg raising was complete to 90 degrees on both sides and there was no evidence of any cord or root compression.

Laboratory Examinations on Admission:

Urine:

Specific gravity	1.006
Albumin	Trace
Sugar	None
Red blood cells	None
White blood cells	5–7 per high-power field
Casts	None
Reaction	Acid

Blood:

Hemoglobin		94 per cent.
White blood cells		6,500 per cubic millimeter
Neutrophils	77 per cent.	
Eosinophils	0	
Basophils	0	
Monocytes	7 per cent.	
Lymphocytes	16 per cent.	

The corrected sedimentation rate (Wintrobe method) was 36 millimeters per hour.

The Kolmer and Kline tests for syphilis were negative. Roentgenographic examination of the chest, spine, and abdomen, as well as intravenous urograms, gave normal findings. The patient was seen by medical and surgical consultants and no definite diagnosis was made.

Further laboratory studies were as follows: The white-blood-cell count ranged from 5,000 to 6,000 over the next few weeks. Hemoglobin fell and was raised only by transfusion. The test for sickling of erythrocytes was negative. Smear for malaria was negative. Routine agglutination tests for typhoid H and O, paratyphoid A and B, and for *Brucella abortus* were negative. Urine culture showed growth of *Bacterium coli*. On September 19, blood culture made on September 13 was reported as being positive for Salmonella, Group C_1. The organism was further identified as *Salmonella cholerae suis*. The same organism was recovered from blood cultures on September 22, 26, 27, and 29, 1951. Blood culture was negative on repeated examinations after November 4, 1951. Stool culture was repeatedly negative for any organism of the Salmonella group, and the organism was never recovered in the urine.

Following admission, the patient continued to have an acute febrile course with temperatures ranging to 102 or 103 degrees daily. An attempt was made to aspirate at the area of tenderness above the ilium, but no fluid was obtained. On September 16, 1951, a course of 100,000 units of procaine penicillin every three hours was begun. When the second blood culture was returned with positive findings, cloramphenicol therapy was begun, one gram and later two grams being given every six hours. Although he continued to complain of some pain in the back, the pain was not as severe as it had been on admission. Tenderness appeared to be more sharply localized to the region just above the iliac crest on the right side. The tentative diagnosis was an abscess, either perinephritic or retrocecal, of appendiceal origin, or osteomyelitis of the ilium

or spine. On October 8, repeat roentgenograms of the lumbar spine showed a destructive process involving the inferior border of the fourth lumbar vertebra and the superior border of the fifth lumbar vertebra, with some loss of disc space (Figs. 1-A and 1-B).

FIG. 1-A

FIG. 1-B

Roentgenograms made four weeks after admission. Vertebral destruction was noted at the margins of the disc between the fourth and the fifth lumbar vertebrae. There was no evidence of extensive abscess formation.

FIG. 2-A

FIG. 2-B

Roentgenograms made approximately ten months after the onset of illness. Vertebral destruction was more pronounced, and there was collapse of the disc.

About one week after chloramphenicol treatment had been started, the temperature trend was downward, although the patient continued to complain of pain in the same region as had been noted on his admission. Exploration for abscess was considered but deferred. On October 17, a plaster jacket incorporating both thighs was applied. Symptomatic improvement was almost immediate and the temperature fell slowly to normal. Chloramphenicol treatment was maintained for a twenty-four day period. For several days after chloramphenicol had been discontinued, the temperature again rose to over 101 degrees, but blood cultures at that time were negative and the temperature flattened out again without further therapy. At the time of discharge, on November 19, the temperature had been normal for a week.

The patient was discharged to a convalescent home in a plaster jacket. He removed this himself and left the home several weeks after his admission there. He was seen again in July 1952. At that time he had no symptoms referable to his spine, although he had not yet returned to work. There was no local tenderness or muscle spasm in the spine and the range of motion in both anteroposterior and lateral planes was at least 75 per cent. of normal (Figs. 2-A and 2-B).

DISCUSSION

The genus Salmonella comprises gram-negative and non-spore-forming bacilli, which as a rule are motile by means of peritrichous flagella. They grow well on ordinary culture media, produce acid and gas from mannitol, maltose, glucose, and sorbitol, do not form indole from peptone, and do not liquify gelatin. They have one common quality: all the known species are pathogenic for man, animals, or both.[1]

Salmonella infection in man is usually one of three types:

1. Gastro-enteritis, varying from a mild attack to the severe type ending in death.
2. Salmonella fever, a typhoid-like febrile illness.
3. A typical septicaemia, the symptoms and findings in individual cases being dependent upon the localization of any abscess.

The organism usually responsible for the third type is one belonging to Salmonella Group C, commonly *Salmonella cholerae suis*. Intestinal symptoms and lesions are usually absent and the organism is rarely recovered from the stool. Diagnosis and identification depend upon isolating the organism from the blood or from a focus of infection. In the case reported, repeated search in the stool and urine failed to demonstrate the organism during the acute phase or during convalescence. Edwards and his associates have reported 3,016 cultures of Salmonella organisms recovered from human sources. Of these, 151, or 5 per cent., were *Salmonella cholerae suis*. Of the total group from human sources, 184 were found in blood cultures, and eighty-four of these, or 45.6 per cent., were *Salmonella cholerae suis*. There were fifty-six fatal cases and *Salmonella cholerae suis* was the organism in twenty-four of these, or 42.8 per cent. Saphra reported a mortality rate of 5.3 per cent. for the entire Salmonella group, but for *Salmonella cholerae suis* the rate was 21.3 per cent. Figures approximating these have been reported by others [7,14,15,21]. It is of interest that of 149 cultures of this organism of known origin, not one was isolated from a normal human carrier.[3] These figures indicate that *Salmonella cholerae suis* infection in man occurs almost always in sporadic form. This is in marked contrast to other Salmonella types and indicates that the sources of *Salmonella cholerae suis* infection in man may not be the same as those of other members of the genus.

Other organisms of the Salmonella genus are responsible for the more common cases of enteritis which usually occur in epidemic form. The common sources of infection are meats of infected animals, sausage, cream puffs, ice cream, puddings, milk, and polluted water. Several epidemics have been traced to duck eggs [17] and isolation of many members of the Salmonella genus from dried egg powder has suggested this as a possible source of infection [18]. Contaminated foods are not altered in appearance, taste, or odor, and the presence of such contamination can be determined only by bacteriological examination. A symptom-free carrier represents a source of potential danger.

The effect of chloramphenicol on the course of the infection in the case reported was not striking. Ross and his associates, in a study of the effect of the drug on cases of enteritis due to a member of the Salmonella genus, concluded that the disease may be

attenuated by its use. Other reports [8,19,21,22] show that some infections have responded dramatically to drug therapy, while others were apparently not affected. Surgical drainage in the present patient was contemplated and would have been performed had he not responded otherwise. Perhaps early surgical intervention would have shortened the course of the infection.

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MULTIPLE LYMPHANGIECTASES OF BONE

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This case report of a disseminated skeletal disease is presented to illustrate the difficulties in classifying an unusual type of multicentric cystic lesion in any of the categories of pathology. The entity, here termed multiple lymphangiectases, presented problems in clinical differential diagnosis which could not be resolved even after numerous biopsies had been done.

The patient was a girl, eight years old, who presented numerous progressive, destructive lesions of bone in which dilated lymphatic vessels were the principal pathological elements. Extensive clinical observation and autopsy findings were not sufficient to classify the process as one of neoplasm, malformation, or inflammation. Search of the literature revealed three similar cases [5, 6] which were considered as neoplasms, either lymphangiomatous or hemangiomatous; the present case report is the first to include an autopsy study of this condition. *

CASE REPORT

The patient became a state ward at the age of three years in May 1947. Her familial and early medical history are unknown, except that she was hospitalized for three months, when she was one year old, for a swelling in the neck region. At three years of age she was noted to have limited motion of the neck; this limitation increased and the region became painful during an acute febrile illness resembling rubella. For this illness she was hospitalized in August 1947. The record of the initial medical examination showed a shortening of the neck and limitation of motion in lateral and forward flexion, with severe muscle spasm. She supported and protected her neck at all times. The neurological examination gave normal findings.

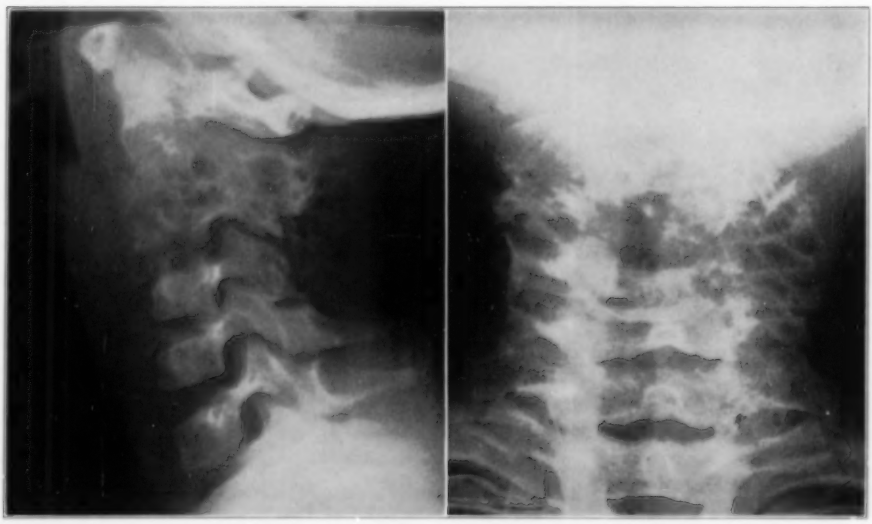

FIG. 1-A

FIG. 1-B

Initial roentgenograms made in August 1947, demonstrating extensive involvement of bodies, laminae, and spinous processes of the third, fourth, and fifth cervical vertebrae. The second cervical vertebra appears to project forward in relation to the third cervical vertebra. There is a characteristic "soap-bubble" appearance. Numerous small cysts are seen in the cancellous bone. No soft-tissue changes can be seen.

* The report by Gorham and his associates appeared after submission of this material. It contains one case study which is similar to the authors' in showing an extensive osteolytic lesion involving a shoulder girdle, but without visceral or disseminated lesions.

The temperature at admission was 101 degrees and the sedimentation rate was thirty-one millimeters in one hour (Westergren method). A hemogram showed moderate leukocytosis. Roentgenograms (Figs. 1-A and 1-B) showed a destructive lesion of the cervical spine and a small cystic lesion in the right humerus. A skeletal survey was otherwise negative. Normal spinal-fluid dynamics were found on lumbar tap and the fluid had a normal protein content. Tuberculin tests were negative. A tentative diagnosis of osteomyelitis was made; treatment consisted in immobilization of the neck, first in a plaster cast and later in a brace. No antibiotic therapy was used. The fever and cervical pain disappeared when the neck was immobilized, but the leukocytosis and elevated sedimentation rate persisted until discharge in February 1948. The roentgenographic findings did not show significant changes.

FIG. 2

A painless limp became evident in May 1948 and roentgenograms (Fig. 2) revealed a cystic area in the right femur. Hospitalization was again instituted. A skeletal survey revealed lesions of both femora and of the pelvis (Fig. 3). A biopsy of the femur was performed and this showed only spicules of bone without inflammation or other cellular infiltration. The cervical lesion had progressed to involve the second and the sixth cervical vertebrae, with some forward flexion and settling of the intervening segments.

Another period of hospitalization for a febrile episode showed no essential change in the lesions of the cervical spine, but healing in the area of the femoral biopsy had taken place. A non-tender, diffuse soft-tissue swelling in the neck appeared two weeks after the third admission to the hospital. This was attributed to pressure of the brace and head sling, but roentgenograms (Fig. 4) revealed a pathological fracture of the clavicle. A biopsy specimen obtained from this area showed no specific lesions. Culture of the bone revealed *Staphylococcus aureus*, hemolytic and non-hemolytic. Intermittent unexplained febrile episodes occurred with persistent leukocytosis and elevated sedimentation rate and a short course of

FIG. 3

Fig. 2: Roentgenogram of the femoral lesion discovered in May 1948, illustrating the type of lesion seen in long bones. It is essentially erosive with no reactive component. The oval shape and rather regular but poorly demarcated outline are typical.

Fig. 3: Roentgenogram, made in July 1948, showing the femoral and pelvic lesions. There are numerous cystic areas, most marked in the right femoral shaft (from which a biopsy specimen had been removed), but also visible in the capital epiphyses, the left femoral neck and shaft, and in the pubis bilaterally. In the left femur some reactive bone formation is evident, an unusual occurrence with this lesion.

penicillin therapy was administered, during which there was a temporary abatement of the fever, but no changes in the spinal or in other osseous lesions.

During the next three and a half years there was a gradual progression of the cervical lesions, with involvement of all of the cervical and the first three thoracic vertebrae (Fig. 5), as well as involvement of other bones: the left first, second, and sixth ribs, and the right seventh rib in 1949, and the left scapula, the left ischium, and the right pubis in 1951. The patient spent most of this period going to school from various foster homes, wearing a brace and later a Thomas collar. In 1949, roentgen therapy was started and 600 r was directed to the cervical spine and a biopsy specimen was taken from the right ilium. The material obtained consisted of bony spicules on which no diagnosis could be based. In May 1951, slight, persistent generalized weakness of both hands developed. Thereafter the patient was twice admitted to the hospital for transitory severe weakness, once of the lower extremities in August 1951, and once of the upper extremities in June 1952. Neurological examinations at both times were negative. In October 1952, she was first seen at The Children's Medical Center because the increasing weakness of all four extremities was such that she was unable to walk and barely able to move her hands. Numbness, coldness, and paraesthesia were present in the lower extremities.

FIG. 4

Roentgenogram showing the clavicular fracture which occurred in October 1948, demonstrating the erosive character of the lesion. The humeral head and metaphysis and the acromion also show small punched-out areas of loss of bone substance, later proved to be lesions.

Physical examination revealed severe cervical truncation, tenderness, and pain on any motion. A

FIG. 5

FIG. 6

Fig. 5: Roentgenogram of the cervical spine made in October 1948. Extension of the process to involve the second, third, fourth, fifth, and sixth cervical vertebrae is evident. There is compression without marked wedging of the bodies of the second, third, fourth, fifth, and sixth cervical vertebrae. Some soft-tissue swelling is evident. The multicentric erosive foci are characteristic.

Fig. 6: Roentgenogram of the cervical spine made in May 1951. Further extension has occurred to the skull and the thoracic spine. The alignment of the cervical spine has become kyphotic, but many vertebrae have completely lost their outlines. The soft-tissue swelling is minimal.

FIG. 7

Photomicrograph (× 100) of a section from the spleen. The enlarged lymphatic spaces are obvious and their continuity with splenic pulp and with lymph channels is illustrated.

depressed softened area (two by two centimeters) in the right parietal region of the skull was present. Shortening and deformity of both clavicles, as well as fullness in the soft tissues over them, were noted. There was moderate atrophy of all extremities, with minimal voluntary motion in the upper and none in the lower limbs. A neurological examination showed diminished muscle power in all four extremities, but no muscle was without some contractile strength. Similarly, below the areas of cranial-nerve innervation the patient was hypo-aesthetic, but all modalities of sensation were present and no areas of anaesthesia were found. The reflexes of the upper and lower extremities were hyperactive. The Babinski reflex was elicited and knee clonus and ankle clonus were present bilaterally. Roentgenograms showed progression of the spinal collapse in the cervical area (Fig. 6). New lesions in the skull, several ribs, left humerus, and right scapula were present, but most of the humeral, pelvic, and femoral lesions showed no progression. On spinal puncture and myelography, a subarachnoid block was found and the spinal-fluid protein was 735 milligrams per 100 cubic centimeters. A fever of 99 to 101 degrees was intermittently present, and the sedimentation rate was elevated, but there was no leukocytosis. Skeletal head traction by means of tantalum bands through burr holes was instituted, with subjective benefit and with some slight increase in muscle power.

In December 1952, two grafts from the bone bank were applied to the spinal laminae from the occiput to the third thoracic vertebra. At operation the exposed laminae and spinous processes consisted of a shell-like cortex under which was a honeycomb of small, thin bony spicules which could be crushed by finger pressure. In the interstices no soft tissue could be seen grossly. No diagnosis could be made microscopically from the tissue removed. It consisted of bony spicules and vascular spaces; no cellular tissue intervened. After operation, head traction was maintained, together with immobilization in a plaster-of-Paris cast. The intermittent febrile course continued without significant neurological change. About four weeks after operation intermittent periods of dyspnoea began to become evident, concomitant with a diminished vital capacity, and it was thought that atelectasis and pneumonitis were present, but examination was difficult because of the plaster cast. Oxygen therapy and respirator care were administered, with temporary benefit, but the patient's condition slowly declined until she died in February 1953, in respiratory failure.

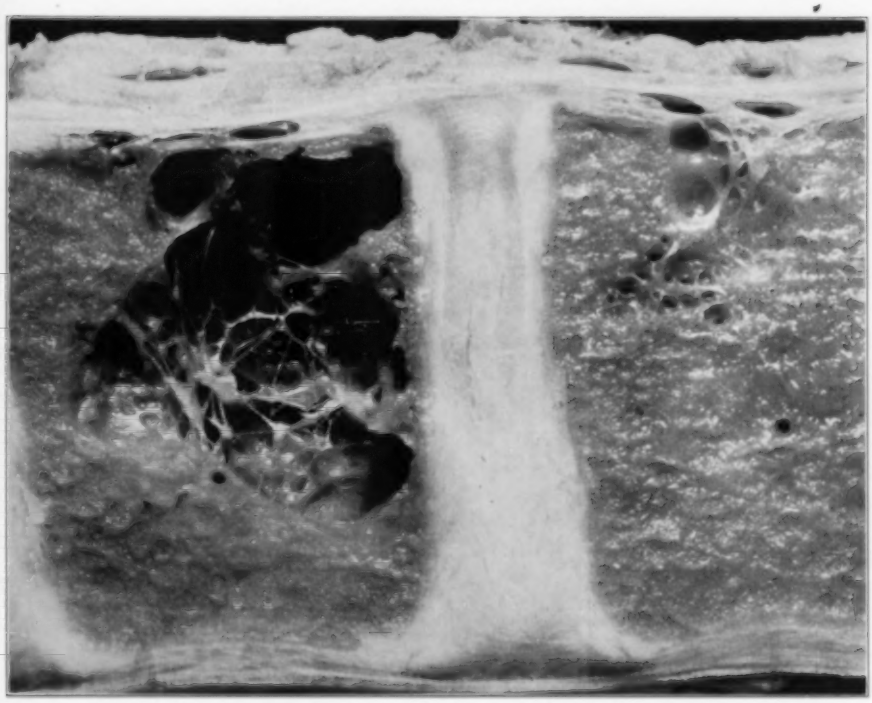

FIG. 8

Photograph (× 4) of a section from the thoracic vertebrae, showing in a thin slice the cystic areas with filamentous vessels or strands of tissue, the only structures within them. The anterior longitudinal ligament is thickened and also contains widened tissue spaces.

AUTOPSY FINDINGS

At autopsy the child was found to be well developed and well nourished. The soft tissues over both clavicles and over the left shoulder and upper arm showed a sharply circumscribed oedematous swelling. On section of the tissue, fluid was evident grossly in the subcutaneous area of these regions. Each pleural cavity contained 700 cubic centimeters of yellow-tinged, opaque, slightly viscous fluid which showed very few cells and which did not contain fat. This fluid compressed the lungs to 10 per cent. of the total space of the pleural cavities and depressed both diaphragms. The lungs were solidly atelectatic and were non-crepitant throughout. Microscopically, the appearance of atelectasis was confirmed. There was also a widespread chronic pneumonitis with numerous macrophages in the alveoli. Septal-cell proliferation was seen in the alveolar walls. Both the visceral and the parietal pleura were greatly thickened by marked fibrosis with moderate infiltration of lymphocytes and plasma cells. The vasculature of the pleura was greatly dilated, although there were no recognizable abnormalities of the lymphatic spaces. The spleen was slightly underweight; it was smooth on the surface, but on cross section numerous cysts were found scattered through the pulp. These were non-contiguous and occurred beneath the capsule and throughout the pulp. They measured two to eight millimeters in diameter and were filled with a clear fluid. They had thin walls and showed no loculation. Microscopically, they consisted principally of a fibrous membrane. An endothelial lining was demonstrable occasionally. Microscopic openings were found in several cyst walls, opening into the pulp and into structures resembling lymphatics (Fig. 7). The kidneys were abnormal only in that they were unequal in size, the right being slightly larger than normal, the left slightly smaller. In one of them there was a single small focus of chronic pyelonephritis. The parathyroid glands showed no evidence of hyperplasia or tumor.

The skull presented many features of interest. Several portions of the calvarium showed localized areas of thinning of the tables and some regions contained small fenestrations. No cystic areas were seen when the calvarium was sectioned. Near the burr holes, areas of reactive thickening and hemorrhage were found. The right bone graft was solidly fused to the occiput, but only a small amount of callus was seen. The left graft was attenuated and attached to the occiput by fibrous tissue. The remainder of the skull, including the base, middle ears, and sinuses, showed no abnormalities.

The cervical spine was removed intact and showed an anterior projection of the second cervical vertebra

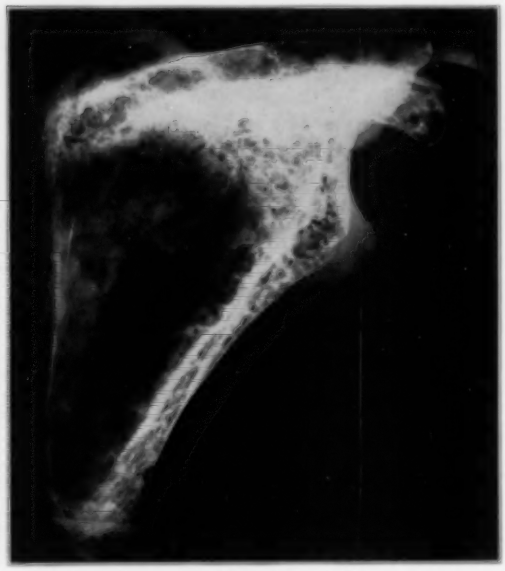

FIG. 9

Postmortem roentgenogram of the left scapula, showing the nearly universal involvement and "soap-bubble" appearance. Compare with Fig. 4 for evidence of extension.

on the third of about two centimeters and a non-angulated kyphosis of the lower cervical segments of 20 degrees. The spinal laminae and spinous processes had been removed operatively and in their stead a dense fibrous tissue was seen enveloping the bone grafts. The right graft at its lower extremity showed fibrous union to the upper thoracic spinal segments; the left was united in that area by a small amount of bony callus. Upon removal of the grafts and fibrous tissue, the spinal cord was exposed and was found to be covered by a nylon membrane. No narrowing of the canal was noted, except at the area of angulation (from the second cervical vertebra to the fourth), where compression of the cord was evident. The bodies of the vertebrae were truncated. When sectioned, they showed complete replacement of the cancellous bone by cystic spaces resembling an irregular honeycomb (Fig. 8). There was an uninterrupted shell of cortex externally, but all of the bone could be crumbled by finger pressure.

The remaining bones, all of which were examined save those distal to the elbows and knees, showed normal external relationships and structure, except for small nodular thickenings in several ribs, both scapulae, and the left clavicle. Sections of the bones revealed numerous areas replaced by cystic rounded cavities measuring up to one centimeter in diameter and grossly containing fluid but no soft tissue. These cavities were usually multiple and sometimes discrete, sometimes confluent; occasionally solitary cavities were found as well. Many areas of bone were devoid of cavities. These areas were uniformly osteoporotic and contained either fatty or hematopoietic marrow, the latter particularly in the long bones and ribs. Those bones, such as the scapulae and ilia (Fig. 9), containing the cystic spaces were frequently covered by a thickened periosteum which stripped easily, leaving a cortex which often could be indented by digital pressure.

Microscopically, many areas of bone showed no pathological findings other than extreme osteoporosis. No abnormalities of the endochondral sequences of ossification were seen at the epiphyseal cartilages. Relatively few centers of hematopoiesis were demonstrable, mainly in the diaphyses of the long bones, and marked by myeloid and plasma-cell hyperplasia The areas of fatty marrow, exemplified particularly in the vertebrae, showed a few small isolated hematopoietic foci. The areas of cavitation, when uncomplicated by fracture, were rather uniform. They consisted of small or large spaces in the bone, occasionally traversed by a few isolated bony spicules, small arteries, fat, and foci of inflammatory cells, and sometimes containing cell-free fluid (Fig. 10). The bony laminae adjoining the cavities were thin and were usually covered by a single layer of flattened cells. Occasionally a band of mononuclear cells, plasma cells, and lymphocytes bordered the cavity and in some areas this type of cellular aggregate seemed to be the salient of erosion of the cortical layer (Fig. 11). Frequent instances of coalescence between the medullary cavities and the lymphatic channels in the periosteum occurred (Fig. 12). The periosteum itself was usually quite thick and contained an abundance of dilated lymphatic vessels with a significant number of perivascular inflammatory foci. The periosteal lymphatics often were continuous, with rather large lymphatic vessels ramifying through the overlying muscle and areolar tissue.

Histological features interpreted as the results of fracture often complicated the picture described (Fig. 13). The characteristic layer of subperiosteal bone resembling callus could often be seen, although the layer of this reactive bone was usually quite thin. In some instances the fracture was evident, while in others the sections did not show the actual fracture area. Some areas of obvious callus formation and fracture into a cyst were found, and in these a fibrous vascular tissue was seen in apposition to the callus. This tissue resembled the ordinary fibrous tissue found in bone repair and was not over-rich in lymphatic spaces, nor were inflammatory elements present. One such area of callus contained considerable cartilage in addition to the fibrous tissue.

The sections containing the grafts showed a moderate amount of dense fibrous tissue surrounding the recipient bed, as well as the grafts. This fibrous tissue contained very few lymphatic channels, but a few

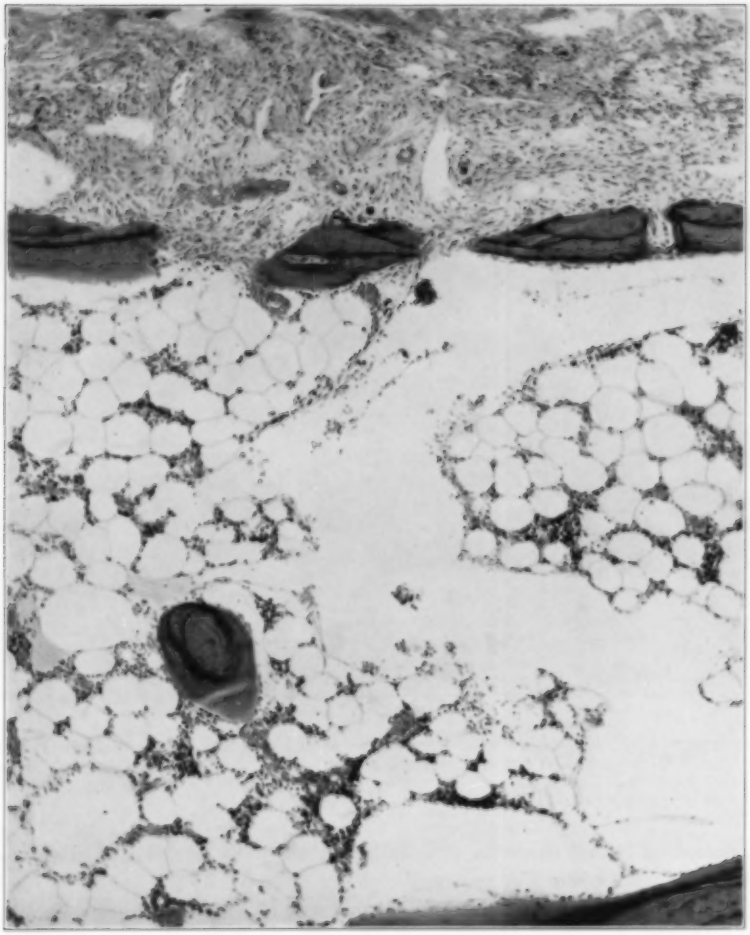

FIG. 10

Photomicrograph (× 100) of a section from the sternum. The thickened periosteum is at the top, with numerous lymphatic vessels and occasional perivascular lymphocytic infiltration. The spaces in the bone are evident. In this field the cortex is very thin and appears to be eroded primarily from the periosteal surface.

small foci of inflammation could be found, some of which were acute, but none of which were adjacent to either the graft or the host bone. Overlying the grafted bone and on the recipient bed there often was a thin layer of reactive bone. The bone graft itself was completely acellular.

The spinal cord was compressed and angulated at the level of the second, third, and fourth cervical vertebrae. It was slightly swollen below the level of the fourth cervical vertebra. At that level there was a rupture of the arachnoid membrane and a herniation of the dorsal columns into the subdural space. Weigert's myelin-sheath stains showed a partial degeneration of the descending lateral and ventral corticospinal tracts in the low cervical region. In the high cervical area the dorsal columns, the dorsal and ventral spinocerebellar tracts, and the spinothalamic tracts also showed degeneration. In the paravertebral area of the cervical cord there was evident atrophy of the muscles with the characteristic picture of the atrophy of denervation. A review of all of the biopsy specimens obtained in the various hospitals showed tissue which resembled that described, but none of these sections were adequate for a diagnosis.

DISCUSSION

The disease process in this case seemed to be one of destruction of bone in many areas by gradual pressure of enlarging lymphatic vessels. These vessels communicated

FIG. 11

Photomicrograph (× 100) of a section from the scapula. Advancing front of marrow cells is seen eroding bone from within. The periosteum (top) shows lymphatic spaces which communicate with similar dilated spaces in the fat above. The marrow cavity is primarily one large unlined space. The cells are mostly monocytes and lymphocytes.

with extra-osseous lymph channels, and, indeed, one of the causes of death presumably was the encroachment of such vessels on the pleura, followed by the accumulation of large volumes of fluid in the pleural cavities. The manner of origin of the anomalous lymph spaces in bone was not apparent. The difficulties in classifying them from an etiological point of view can be illustrated by considering the arguments for or against each possible classification.

1. *Neoplasm*

Clinically, a slowly progressive, destructive lesion, with minimal systemic symptomatic manifestations, inevitably calls to mind a neoplasm, especially when, over a period of years, new lesions crop out in far removed areas. However, if this case represented a neoplastic replacement of bone by lymphatic vessels, the histological character of the vessels should conform to those of a lymphangioma. In this case, the dilated lymphatic spaces were lined by endothelium, often difficult to demonstrate, and always devoid of the usual loose connective-tissue framework of the tunica adventitia, which is characteristic of lymph vessels in a lymphangioma. Evidence of the proliferation of the vessels—that is, mitosis of the endothelial cells—was not found. While all the lesions were similar histologically, interpretation of their occurrence as metastases, in the absence of any evidence of proliferation, is inconsistent with the usual concept of metastatic involvement. Moreover, the local extension of the destructive process could better be described as an obliteration of existing bone and marrow with replacement by dilated sinusoidal spaces, rather than a destruction of tissue by those vessels. The lack of invasion of neighboring

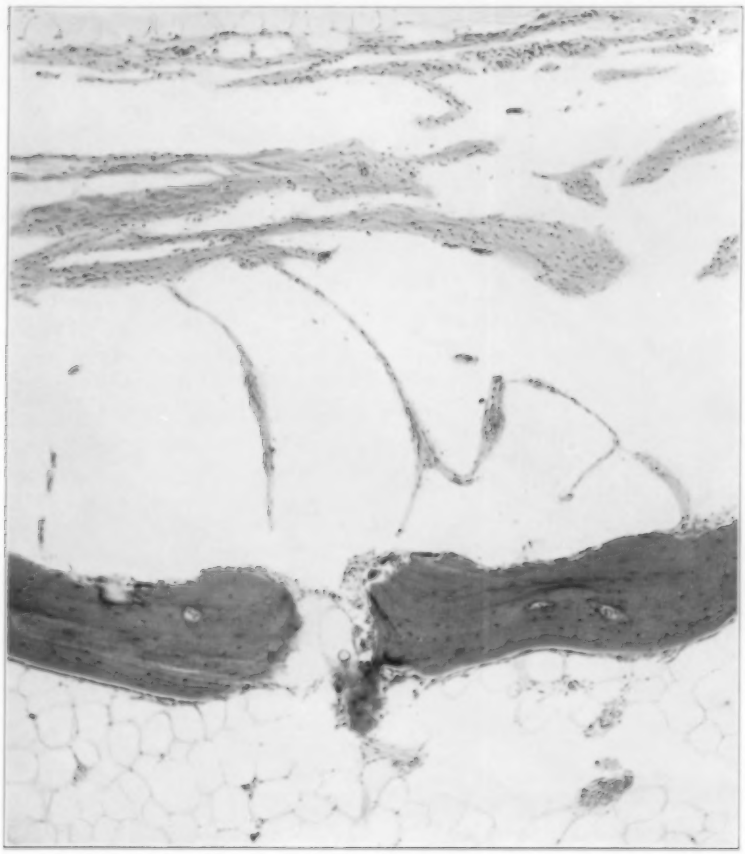

FIG. 12

Photomicrograph (× 100) of a section from a vertebra. The periosteum (top) contains widely dilated lymphatic spaces which communicate with similar spaces through the thin cortex. They also communicate with lymphatic spaces in the surrounding tissue. The periosteum resembles lymphangiomatous tissue in many respects.

soft tissues after the bony cortex had been broken through is incompatible with neoplastic infiltration in its usual sense, despite the coalescence of the intra-osseous and extra-osseous lymphatic channels. Finally, when the possibility of interpreting the lesions as neoplastic is considered, it should be pointed out that, were the osseous lesions, with the exception of that of the cervical spine, metastatic, it would be improbable that the only extra-osseous spread would be to the spleen, notorious for its infrequent involvement by metastasis.

2. *Inflammation*

Certain features of the clinical course of this patient were indicative of some type of inflammatory lesion. The frequent febrile episodes, leukocytosis, and elevated sedimentation rate were prominent findings. Indeed, the initial working diagnosis was osteomyelitis of the cervical spine, tuberculosis being considered unlikely because of the negative tuberculin reactions. As the lesions progressed, it became evident that a primary infection was improbable, especially since biopsies showed no inflammatory tissue. The postmortem specimens did show areas of slight chronic inflammation, and it becomes necessary to consider whether or not the entire lesion could be a bizarre type of inflammatory response. The evidence against this interpretation is overwhelming. Inflammatory components

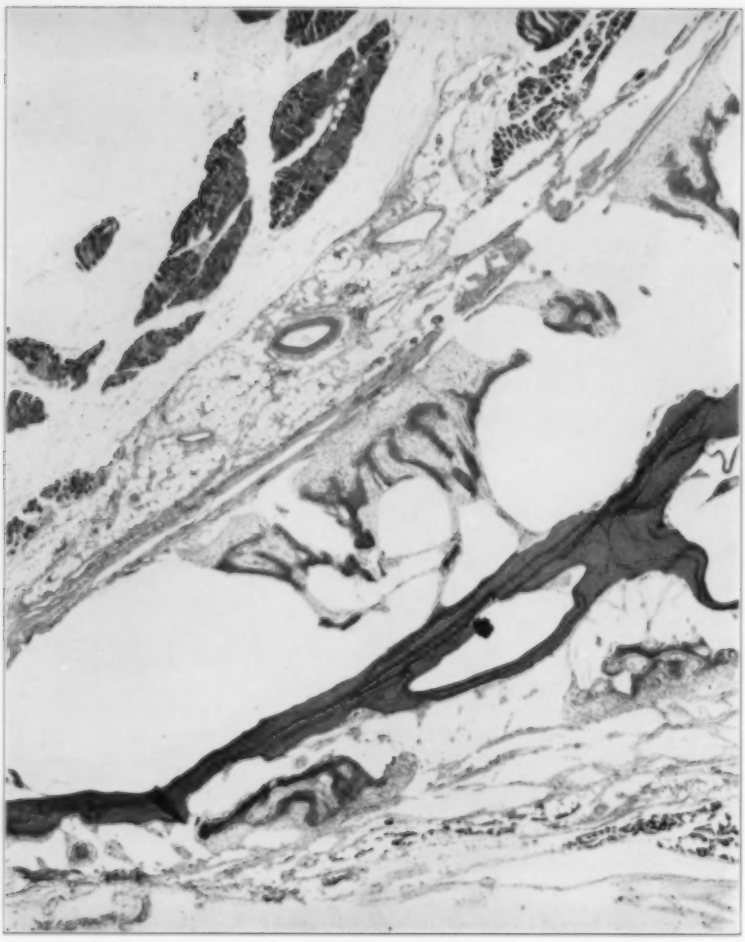

FIG. 13

Photomicrograph (× 60) of a section from the spine of the scapula. At the left is the posterior edge and at the right the two tables diverge to enclose a lymphatic space. Subperiosteal callus is present on both sides of the bone. This presumably is the result of minute fractures in an adjacent area. Lymphatic spaces abound in the periosteum and course through the callus.

were so infrequent that they had to be sought for in many sections; a similar anomalous reaction in repair of other tissues by lymphatic vessels has not been described; repair sequences in the operative sites were of the usual type.

3. *Obstruction*

Any dilation of the lymphatic vessels calls to mind the possibility of obstruction to lymph flow. The multicentric foci unrelated to any anatomical distribution of lymphatics preclude this explanation.

4. *Malformation*

Bizarre examples of congenital anomalies involving lymph vessels are well documented, and this case may represent one more such instance. The history of its onset at an early age may be mentioned, and its slowly progressive course in the cervical spine is not inconsistent with the enlargements of lymphatic vessels contained in the anomalies,

such as Milroy's disease and cystic hygroma. Postnatal outcropping of new lesions in areas apparently originally uninvolved is very unusual, and the concept of postnatal anomaly formation *de novo* is hard to accept even in the absence of other possible etiological explanations. Anomalies of postnatal growth without complicating factors such as trauma are seldom as outspokenly destructive of preformed, normal bone as in this case, although neurofibromatosis and certain types of bone cyst may well constitute analogous entities.

Very little is known concerning the normal anatomy of lymph vessels in bone, except that blood vessels always contain these structures in their walls. Any explanation of the origin of the lymphatic spaces from lymphatics accompanying blood vessels, while a possibility, should be supported by the presence, histologically, of blood vessels within the lesions. These were notably absent.

Multiple small splenic cysts, which are not infrequently found in routine postmortem studies, have been commonly interpreted as congenital anomalies, and their presence in this case adds weight to this line of etiological explanation. However, the problems of the manner of local spread and the factors governing the multicentric outcropping remain unanswered in this interpretation.

Comparison of this case with those in the literature of similar character is of interest. The three cases described by Jacobs and Kimmelstiel and by Harris and Prandoni seem identical. The titles of their reports—"Cystic Angiomatosis of the Skeletal System" and "Generalized Primary Lymphangiomas of Bone"—indicate that the authors prefer the classification of neoplasm. The term lymphangiectasis, on the other hand, was selected to call attention to the difficulties involved in classification. Similar terminological difficulties are encountered in other vascular lesions, such as Sturge-Weber's disease or Milroy's disease, in which the demarcation between malformation and tumor is uncertain, despite the progressive nature of the lesion.

A similar case was that of Parsons and Ebbs in which, in addition to the bone lesions, extensive visceral involvement occurred and histologically, in addition to lymphatics, blood vessels were encountered. The present patient showed only minimal involvement of the spleen and of the soft tissues adjacent to involved bones. This seemingly is a point of clinical differentiation, but may only indicate different degrees of the same pathological process. Bickel and Broder's case, while presenting only a single lesion which involved one side of the pelvic girdle, was similar, roentgenographically, histologically, and in its chronic progression.

Separation of these cases from those termed hemangiomata of bone seems to be worth-while, inasmuch as the latter show marked roentgenographic and clinical differences. Particularly, hemangiomata of the vertebrae, as described by Töpfer and by Bucy and Capp, with their coarse trabeculations and asymptomatic, non-progressive course, can hardly be included in the same group as the present case. Hemangiomata of bones of the extremities, as in the cases reported by Thomas and by Ackermann and Hart, may also be differentiated on similar grounds.

Serious difficulties in differential diagnosis from fibrous dysplasia, eosinophilic granuloma, and atypical osteomyelitis were encountered during the clinical course of the authors' patient. Several biopsies were done to clarify the diagnosis and a review of the sections showed that, as is so often the case with biopsies of bone, only small fragments were obtained because of the friable character of the lesion. Only in retrospect can a diagnosis be made from these sections, but it is well to point out that more extensive tissue removal, including adjoining soft tissue attached to the bone, might have allowed a diagnosis to be made while the patient was still alive. This point is the more cogent since repair of the biopsy area was quite adequate and therefore it is possible that a more radical early surgical approach to therapy, including use of bone grafts over a large area, may have been indicated.

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DISCUSSION

Clinical Evaluation of Freeze-Dried Bone Grafts

(*Continued from page 566*)

Is the preservation of living cells clinically significant? The answer to this question is to be found in a better understanding of the fate of living cells in homogenous bone grafting, and this still remains to be clarified. Homogenous grafts of embryonic bone apparently survive better than homogenous grafts of adult bone [c]. The incidence of survival seems to depend, among other factors, on inbreeding of the experimental animal and the volume of the graft.

Capt. Carr and Lt. Cmdr. Hyatt have stated that freeze-drying requires expensive equipment and is not adaptable to the average hospital.

It is hoped that the results of current studies will provide us with the answers to some of the foregoing questions. When we know what component or components are important in the replacement of non-viable grafts, when we know what we are trying to preserve in bone grafts, we will be in an even better position to improve further our methods of preservation.

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Dr. Charles H. Herndon, Cleveland, Ohio: In 1951, I presented before this organization the results of experimental studies with massive autogenous grafts, direct homogenous grafts, and frozen homogenous grafts. This study has been continued. We have found that, although the homogenous grafts are revascularized almost as rapidly as autogenous transfers and although x-ray results may be analogous for months, resorption and appositional new-bone formation is long delayed—at times for years—and eventual disintegration of the graft is common.

The cause for this difference in behavior is not known. Type specificity of one sort or another is probable. At present, we are investigating the problem from an immunological approach, but as yet we have no answer.

I have not had personal experience in the use of freeze-dried homogenous bone and have been quite impressed with the authors' results. They have made a valuable contribution to bone-graft surgery in developing a satisfactory method of bone preservation at room temperature.

(*Continued on page 614*)

POSSIBLE CAST SYNDROME

Report of a Case

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The so-called cast syndrome has been described as a train of events including gastric dilatation, pernicious vomiting, and severe electrolyte disturbance following the application of a body cast. The case here presented differs from others reported in the literature in that the symptoms occurred after the cast had been removed and then had been reapplied. It is especially interesting because of the severe electrolyte imbalance which was observed and the fact that the patient survived in spite of levels of electrolyte disturbance which are generally accepted to be lethal.

A twelve-year-old girl was admitted to the University of Virginia Hospital on December 27, 1952, with the chief complaint of protracted vomiting for two weeks and what appeared to be *grand mal* convulsions of one day's duration.

The child had been in excellent health until July 1952, approximately six months prior to admission, when she was first noticed to have a thoracic scoliosis at the level of the eighth and ninth ribs. This had apparently coincided with the period of accelerated growth. She had been put in a body cast for correction of the deformity on September 1, 1952, approximately three and one half months before the onset of the present illness. She had done well until two weeks prior to admission, at which time the cast had been removed and a new one had been applied. On the following day, the child had complained of abdominal pain and had begun vomiting, which continued for three days. Medicine prescribed by her local physician had stopped the vomiting for three days, and the child had returned to school. One week prior to admission to this Hospital, she had begun vomiting again, and this time medications were of no avail. The vomiting was projectile and intractable, occurring night and day, and was associated with abdominal pain.

Two days prior to admission to this Hospital, the child had been admitted to another hospital and had been given clyses of glucose and water and glucose and saline. Because of marked abdominal distention, Wangensteen suction had been instituted. Tests for non-protein nitrogen had shown 170 milligrams per 100 milliliters, in spite of the fact that the urinalysis had been negative with a specific gravity of 1.032. Routine blood counts had not been remarkable. A lumbar puncture had revealed normal values for the cerebrospinal fluid. The child had had no bowel movement for five days prior to being transferred to our Hospital. The body cast had been removed the day prior to the admission to this Hospital on December 27, 1952.

On the day of admission she had apparently had three *grand mal* convulsions lasting three to five minutes, followed by extreme restlessness and raving delirium.

Past history, family history, and review of systems were essentially non-contributory, except for a divergent strabismus which had been present since birth. On examination, the patient was found to be a well developed and well nourished white girl of twelve years who was completely disoriented, thrashing wildly about the bed, unresponsive and uncooperative. The significant physical findings were her temperature of 97.6 degrees, pulse 100, respirations 22, and blood pressure of 117 (millimeters of mercury) systolic and 80 diastolic. The eyes showed a divergent strabismus, and the pupils were dilated and sluggishly reactive to light. The fundi were normal. Ear, nose, and throat examination gave normal findings. The neck was supple. The chest was clear to percussion and auscultation. The heart was not enlarged to percussion, and rate and rhythm were regular. A loud, blowing, high-pitched systolic murmur was heard, loudest in the third and fourth interspaces on the left of the sternal border. The spine showed a right thoracolumbar curve of 30 degrees, greatest at the level of the seventh to the tenth thoracic vertebrae, which involved the entire lower thoracic and upper lumbar areas. The abdomen showed spasm of the entire right rectus abdominis. No definite mass was felt. The left rectus abdominis was completely flaccid, and peristalsis was absent except for an occasional gurgle. Neurological examination revealed right facial weakness, as well as weakness and spasticity of the entire right side. Deep tendon reflexes were diminished on the right, and abdominal reflexes were absent on the right. No Babinski response was elicited.

The laboratory findings showed:

Blood	
Hemoglobin	15.5 grams per 100 milliliters of blood
Red blood cells	5,360,000 per cubic millimeter of blood
White blood cells	17,500 per cubic millimeter of blood, with some shift to the left
Blood urea nitrogen	200 milligrams per 100 milliliters
Urine	
Color	Yellow, clear
Reaction	Acid 5.5 pH
Specific gravity	1.011
Sugar	+ + +
Albumin	0
White blood cells	0 — 1 per high-power field
Red blood cells	0
Casts	0

On admission, the patient was given phenobarbital to control the convulsions, and a Levin tube was passed into the stomach in order to feed her. She did not vomit during her entire stay in the Hospital. Her urine output was fair; the measured output was 300 milliliters in the first twenty-four hours, although the child had voided several times involuntarily during this period. It was not realized that she was so severely dehydrated as she subsequently proved to be, because her skin turgor was good and her output of urine was fair. It was felt that she could be hydrated satisfactorily by mouth.

Retrograde pyelograms were done because it was our initial impression that she had, possibly, a right renal tumor with cerebral metastases accounting for the convulsions and right-sided findings on admission. The pyelograms showed normal renal outlines; it was felt then that the azotaemia was prerenal and was orobably caused by dehydration.

Thirty-six hours after admission, laboratory findings were reported as follows:

Electrolytes	Milliequivalents per Liter	Milligrams per 100 Milliliters
Chloride	38.5	225.0
(Repeated six hours later)	35.9	210.0
Urea		216.0
Potassium	2.3	9.0
Sodium	128.0	295.0
Calcium	8.8	17.5
Carbon dioxide	38.7 (86.2 volumes per 100 milliliters of blood)	

Unfortunately, the calcium determination was not checked and is perhaps inaccurate.

Electrocardiograms showed a rate of 108 with Q–T interval of 0.44. The T waves were suppressed in leads II and leads V_4 and V_5, which was consistent with the potassium deficiency.

It thus became evident, somewhat belatedly, that this child was indeed severely dehydrated with marked alkalosis, in spite of the acid urine. Fluids were started intravenously at both ankles, and in the first twenty-four hours she received fourteen grams of potassium chloride and thirteen grams of sodium chloride in approximately 4,000 milliliters of 5 per cent. glucose in water. After the first twelve hours of fluids, the child's condition appeared much worse; 1,500 milliliters of black fluid had been removed from the stomach in the morning and an additional 1,000 milliliters of fluid was removed that afternoon. Three hours later, another 300 milliliters of fluid was removed from the stomach.

Because of her rapidly deteriorating condition, the fact that she was obviously losing electrolytes and fluids far in excess of the amounts she was receiving by vein, and the findings of spasm on the right side of the abdomen which persisted in spite of the deep coma, it was felt by our surgical consultant that a high intestinal obstruction had to be ruled out. Roentgenograms of the abdomen showed no gas in the gut below the stomach. She was, therefore, taken to the operating room, where an exploratory laparotomy was done under local anaesthesia. At operation, she was found to have a large, dilated, and atonic stomach and duodenum, with no evidence of mechanical obstruction. However, the entire small and large bowel was flat and ribbon-like. After the ligament of Treitz had been divided, the first portion of the jejunum uncoiled somewhat and air began to fill the small bowel. The surgeon felt that the cutting of the ligament did not represent the release of an obstruction but that the movement of air probably resulted from manipulation of the bowel and from the use of an oxygen mask during the procedure. The operation lasted less than twenty minutes, and the child was returned to the ward, apparently none the worse for the procedure. Her blood pressure, pulse, and respirations remained completely stable.

Following the operation, the child began to improve, and peristalsis became audible twenty-four hours

after operation. It was our impression that the operative procedure definitely contributed to her improvement, perhaps by favoring absorption of electrolytes and fluid. During the forty-eight hour period following, a total of 2,000 milliliters of dark brown fluid was removed from the stomach by means of the Levin tube; this amount decreased to only 250 milliliters by the third postoperative day.

The child continued to be somewhat irrational, with periods of twitching, until the sixth day of treatment, and cyanosis was observed on the fifth day. She was started cautiously on sips of water, and gradually nutrition was increased to a full diet. She continued to receive intravenous fluids, eight grams of potassium chloride and twelve grams of sodium chloride per day in 3,000 milliliters of 5 per cent. dextrose in water, for four days; and then her potassium requirements were given by mouth in the form of meat extract. By the eighth day of therapy, the child was taking adequate fluids by mouth and had rather dramatically improved. She became almost completely rational and asked for food. Her electrolyte balance steadily improved in the meanwhile (Table I), and she was placed on a soft diet which she tolerated well.

Intravenous fluids were stopped on the ninth day, and the electro-encephalogram was reported as follows: "The record shows a marked, diffuse abnormality with definite paroxysmal features. These findings indicate a diffuse cerebral dysfunction, the etiology of which is uncertain. A convulsive disorder, toxic or metabolic disturbances, or a combination of various factors could produce this picture, as could some deep-level brain disturbance. Whatever its cause, some of the abnormality in the E.E.G. is directly related to the patient's stuporous condition."

Another electro-encephalogram was made six days later and was reported as follows: "The record continues to show a mild to moderate diffuse abnormality with some minor paroxysmal features, but there has been a very marked improvement as compared to the previous record. These findings, while in no way specific, are consistent with the clinical impression of encephalitis." This was coincident with the improvement in her electrolyte balance.

By the twelfth day of treatment, the patient had improved enough to permit the release of the special nurses, and she was moved into the open ward. She was discharged on the twenty-second hospital day on limited activity, gradually to be increased.

One month after discharge, she was again admitted for re-evaluation. She had been perfectly well in the interim and an electro-encephalogram made at this time showed: "The record continues to be abnormal with some paroxysmal features and some questionable emphasis on the left. As compared to the last record, there has been some definite improvement in the general background, and the over-all picture is probably improved in spite of the persistent and slight increase of the paroxysmal features."

General physical findings were negative except for the thoracic scoliosis previously noted. Laboratory findings were within limits of normal. To date, the patient has been completely well as far as is known, and apparently she has no permanent disability from her illness.

DISCUSSION

We consider that this patient probably represents an example of the so-called cast syndrome.

The onset of pernicious vomiting following the application of a body cast was first described in the literature in 1878 by Willet, who reported the occurrence of this syndrome in a seventeen-year-old boy who had been placed in a body cast (Sayre jacket) for correction of kyphosis of the thoracolumbar spine. One week after the cast had been applied, the patient died following pernicious vomiting. At autopsy, acute gastric dilatation was found.

Dorph reviewed the literature in 1950 and was able to find only four cases reported, to which he added a report of his own and an unpublished case seen at Temple University, bringing the total to six cases. In every instance, acute gastric dilatation was present. The onset of symptoms varied from two days to six weeks after the cast was applied. Of the five reported cases, only one patient survived. All of these patients were adolescents under the age of twenty-two. Several of these authors cited other cases occurring in their experience which had not been recognized or had not been reported.

The etiology of pernicious vomiting from acute gastric dilatation is obscure. Many theories have been suggested. Leucutia feels that perhaps acute dilatation is the result either of the "hyperextended position of the spine . . . or of the considerably reduced excursion of the abdominal muscles. By following the theory of Rokitanski both of these factors could lead to a compression of the third portion of the duodenum by the mesentery and the superior mesenteric vessels. A concomitant participation of the duodenum and

TABLE I

CHEMICAL DETERMINATIONS

Date	Day of Therapy	Chloride		Carbon Dioxide		Urea	Sodium		Potassium	
		Meq. per L.	*Mgs. per 100 Ml.*	*Meq. per L.*	*Vols. per 100 Ml.*	*Mgs. per 100 Ml.*	*Meq. per L.*	*Mgs. per 100 Ml.*	*Meq. per L.*	*Mgs. per 100 Ml.*
Blood										
Dec. 27						200				
Dec. 28										
Dec. 29	First	38.5	225	38.7	86.2	216	128	295	2.3	9.0
Dec. 29		35.9	210							
Dec. 30	Second	40.2	235	37.8	84.3	162	126	290	2.1	8.03
Dec. 31	Third	46.1	270	37.8		176	124	285	3.25	12.68
Jan. 1	Fourth	56.4	330	38.8	86.3	156	110	253	4.5	17.5
Jan. 2	Fifth	63.3	370	31.0	68.8	148	128	295	5.0	19.5
Jan. 3	Sixth	77.8	455			137	126		5.75	
Jan. 4	Seventh	82.9	485	27.8	61.8	134	126		4.0	
Jan. 5	Eighth	82.9	485			122	130		3.5	
Jan. 6	Ninth	81.2	475							
Jan. 7	Tenth	88.9	520	27.9	60.2	80 (?)	152		4.25	
Jan. 10	Thirteenth					53				
Jan. 15	Eighteenth					29				

stomach in the process of dilatation, as demonstrated at all postmortem examinations, lends considerable support to such assumption." The findings at operation in our own case would lend further support to this idea.

By the time studies were undertaken here, the patient's electrolyte imbalance had become so profound that there was almost complete atony of the gastro-intestinal tract. The gastric and duodenal dilatation up to the ligament of Treitz in our case corresponded very closely to the autopsy findings in two other cases reported. Buzzard's case showed kinking of the duodenum at the eight-to-ten-inch level at the ligament of Treitz with the bowel flat below it. Dorph's case also showed dilatation up to the ligament of Treitz with no evidence of organic obstruction, a finding identical with that in our own case. The findings in the other cases at autopsy showed dilatation and in one instance perforation (of the fundus of the stomach) and peritonitis; there was only a dilated stomach without evidence of obstruction in the other cases.

Several recent writers have drawn attention to the fact that the application of a body cast was not appreciated as a factor in the production, aggravation, and sequelae of acute gastric dilatation. Dorph's excellent review of the literature brings this point out rather forcibly. Leucutia comments that Borchgrevink reported on a series of 138 cases of acute gastric dilatation and found seven cases associated with deformities of the spine, but he did not apparently regard the possibility of acute dilatation arising as a result of the application of a body cast.

A most striking feature of our own case was the extreme degree of electrolyte disturbance present which the patient survived. This is the lowest blood chloride ever observed in this Hospital in a case in which the patient survived. It is felt that the symptoms of disturbance of the central nervous system, which were so prominent, were the result of the profound electrolyte imbalance.

In the treatment of this patient, it was first felt that, in view of the marked alkalosis,

large amounts of saline were indicated. However, with an acid urine in the presence of a carbon dioxide combining power of 86.2 volumes per 100 milliliters, it became manifest that the situation was that of a hypokalemic alkalosis, and, thus, more sodium at this point would probably have proved fatal, as it would have promoted further potassium diuresis and driven more sodium into the cells. Therefore, she was given a large amount of 1 per cent. potassium chloride intravenously before any sodium chloride was started. Fluids were given in both ankles intravenously, potassium chloride in one and sodium chloride in the other, every attempt being made to prevent further potassium loss and to replace fluids and other electrolytes.

A suggested explanation for the continued output of urine in spite of the marked fluid deficit is the observation that, experimentally, in animals with low potassium syndrome, the volume of urine output may be large — as there is no means whereby the kidneys will retain potassium. There was also, obviously, a severe derangement of renal function, as shown by the persistent elevation of urea after hydration and after the electrolyte balance had become fairly well established.

Also a factor in the production of this syndrome is the lack of potassium intake in addition to the excessive loss of potassium through vomiting. Another important factor was the fact that, at the first hospital, the patient had received sodium chloride in clyses, as well as clyses of glucose in water, both of these tending to produce further potassium diuresis.

It was considered that surgery in this case was indicated, in view of the good clinical evidence of high intestinal obstruction and the patient's rapidly deteriorating condition. We concurred in the decision of the surgical consultant that operation had to be undertaken to rule out a mechanical cause of obstruction. Although we have no adequate explanation for the filling up of the bowel during the course of operation, it is interesting to note that the first signs of improvement were noted within a few hours after the child had been returned from the operating room. Our medical consultant felt that this child should not have been subjected to operation, in view of her critical electrolyte imbalance, and maintained that all of her symptoms were explained on the basis of electrolyte disturbance.

Attention is again called to the possibility that application of a body cast may be implicated in the initiation of acute gastric dilatation. Death is a possibility unless there is early recognition of the condition and vigorous therapy is instituted.

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FIBROSARCOMA OF THE EXTREMITIES

Review of Forty-five Cases

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Fibrosarcoma offers a rather poor prognosis; however, some of its characteristics indicate that most of the patients with this lesion should and could be cured. This tumor occurs rather infrequently, and many physicians probably are not familiar with the optimum treatment. Hence, the initial therapy is often inadequate, a fact which undoubtedly contributes to the poor results reported.

This study is based on a series of forty-five cases of fibrosarcoma of the extremities seen at the Scott and White Clinic from 1930 through 1952. All of our forty-five cases were reviewed pathologically and were graded according to degree of malignancy. Distribution was as follows:

Tumor Grade	Number of Patients
1	15
2	12
3	7
4	11

Thirty-five of these patients were seen prior to 1948, and they form the basis for survival statistics. Fibrosarcoma occurs in nearly every portion of the body, but this study is limited to those patients with lesions of the extremities.

We wish to suggest the possibility that the connective tissue adjacent to fibrosarcoma has a predilection for malignant change. There are indications that this is true, and, if so, treatment should be modified accordingly.

Fibrosarcoma, a malignant neoplasm, arises from fibroblasts. Grossly, it is usually a firm, gray mass of tissue. Often the tumor appears to be encapsulated. Most authors agree, however, that this is a pseudocapsule resulting from tissue compression over the expanding lesion. If the lesion is a large one, there may be areas of degeneration. Fibrosarcoma is often confused with other malignant neoplasms, such as synovial sarcoma, osteogenic sarcoma, and rhabdomyosarcoma. This is understandable, as grossly and microscopically these lesions may resemble fibrosarcoma. Many benign lesions of the extremities, too, have been diagnosed erroneously as fibrosarcomata. This is especially true in Dupuytren's contracture of the palmar and plantar fascia. Until recently, neurogenic sarcoma (or neurofibrosarcoma) was not considered to be of fibrous-tissue origin; however, today, primarily through the efforts of Stout, this tumor is classified as fibrosarcoma. In our series, we have reviewed and included seven tumors previously diagnosed as neurofibrosarcoma. These difficulties of diagnosis and classification have been confusing factors in the study of fibrosarcoma.

INCIDENCE

This lesion is not a rare one, but fibrosarcoma does occur so infrequently that one observer seldom sees a large number of cases. During the twenty-two-year period in which our forty-five cases of fibrosarcoma of the extremities were observed, 237,065 new patients

were seen at this Clinic. This is an incidence of 0.19 per cent. or approximately two cases per 10,000 patients. Meyerding, Broders, and Hargrave reported an incidence rate of one case per 4,000 patients. Pack and Ariel, in reporting a series of thirty-nine patients with fibrosarcoma of the extremities, stated that this lesion comprised 5.4 per cent. of malignant lesions of the soft somatic tissues.

ETIOLOGY

Although the cause of fibrosarcoma is unknown, there are a number of etiological factors which should be considered.

Trauma

As in nearly all tumors of the extremities, trauma occasionally is mentioned as a contributing factor, but there is little evidence to support such a theory. Three patients in our series (6.7 per cent.) gave a definite history of localized trauma followed by tumor formation. Meyerding and his coworkers noted a relationship between trauma and tumor in 11.2 per cent. of their patients. Ivins and his coworkers found this relationship in only one of seventy-eight cases, and Pack and Ariel reported no instance of tumor formation following trauma.

Fibrosarcoma may develop in scar and granulation tissue. Ewing called such tumors "granulation tissue sarcoma". It is difficult, however, to ascertain if such previously damaged tissue is really more susceptible to this neoplasm. Stout reported thirty-six patients with tumors arising in scar tissue. In our series, no lesion developed in scarred or ulcerated tissue.

If one considers irradiation as another form of trauma, more support can be given to the theory of trauma as an etiological agent, because there does seem to be mounting evidence of the relationship between the development of malignant neoplasms and the roentgen therapy to benign lesions. In one of our patients, fibrosarcoma developed following roentgen therapy to an apparently benign bone cyst. Stout cites four instances of fibrosarcoma occurring in areas of irradiation fibromatosis.

Malignant Transformation

In the consideration of etiological factors, malignant transformation of previously benign lesions also must be mentioned. This includes benign fibroma as well as other benign lesions, such as osteitis fibrosa cystica and myositis ossificans. In one patient in our series, a fibrosarcoma developed apparently from a previously benign tumor. This patient, a woman of forty-five years, had a mass on her left thigh. She stated that it had been present all her life, but that, suddenly, it had begun to enlarge. When removed, the tumor was found to be a fibrosarcoma. It is difficult to believe that this patient had had a malignant lesion for such a long period of time. It seems more probable that the tumor was originally a benign lesion which later underwent malignant change. The precipitating factor of such malignant transformation, if and when it does occur, is still undetermined.

Congenital and Hereditary Factors

A congenital etiology was suggested in one case reported by Pack and Ariel and in one case reported by Meyerding and his coworkers. In both of these cases, the tumor was apparently present at birth. No such case occurred in our series.

Heredity seems to be of little or no importance as a predisposing factor in the development of fibrosarcoma. In our series, only nine patients (20 per cent.) gave a family history of malignant lesions. This compares with the 17 per cent. incidence reported by Meyerding and "is considerably lower than the incidence given by Deelman in a study of the occurrence of cancer in the families of 250 non-cancerous persons".

TABLE I

LOCATION AND GRADE OF MALIGNANCY OF FIBROSARCOMA OF THE EXTREMITIES IN FORTY-FIVE PATIENTS

Location	Grade 1	Grade 2	Grade 3	Grade 4
Foot	0	1	0	1
Leg	2	1	0	0
Thigh	4	7	3	9
Hand	3	1	1	0
Forearm	0	1	0	0
Arm	6	1	3	1

Age and Sex

Fibrosarcoma occurs at any age. It is, however, more common in the middle decades. Ages in our series range from four months to seventy-seven years, with an average age of approximately forty-five years. There was no significant relationship between the grade of tumor and the age of the patient.

Classified according to sex, there were twenty-five females and twenty males in our series. Meyerding and his coworkers and Ivins and his colleagues found a definite preponderance of males in their series. Pack and Ariel and Stout, however, observed the incidence to be greater in females than in males. In occurrence of this tumor, probably there is no real statistical difference between the sexes.

Location

The thigh was the most common tumor site in our series,—51 per cent. of the fibrosarcomata occurred there. Of the lesions, 62 per cent. occurred in the lower extremity, and 38 per cent. occurred in the upper extremity. The larger tissue mass is the only apparent reason for the lower extremity being the more common site. There was no significant variation of tumor grades according to location (Table I).

Symptomatology

Most patients with fibrosarcoma are aware of the presence of a mass for many months before consulting a doctor. Only nine patients in our series (20 per cent.) had had symptoms for less than six months; and eleven patients (24.4 per cent.) had had symptoms for over five years. This long duration of symptoms suggests that more people with this lesion could be cured.

The most common symptom was the presence of a mass. Thirty-eight patients (84.4 per cent.) gave this complaint. Eleven patients (24.4 per cent.) complained of pain; and only three (6.7 per cent.) complained of impairment of function. The fact that in the majority of patients the mass is painless and does not interfere with activity probably accounts for the long delay in seeking treatment. The general public, however, is becoming increasingly "cancer conscious"; and, consequently, a better opportunity for early treatment of fibrosarcoma should be afforded in the future.

Diagnosis

Fibrosarcoma must be considered as a possible diagnosis for all abnormal soft-tissue masses in the extremities. The insidious onset, slow growth, and asymptomatic nature of the lesion need not be misleading. Microscopic examination is the only definite diagnostic method for fibrosarcoma; and, if more of these patients are to be cured, we must not be reluctant to obtain biopsy specimens from these apparently benign soft-tissue masses in the extremities.

TABLE II

METASTASES IN FIBROSARCOMA OF THE EXTREMITIES

Sites of Metastasis	Grade 1	Grade 2	Grade 3	Grade 4
Lung	2	2	4	2
Lymph nodes	0	0	2	0
Abdomen	3	0	2	1
Axilla or inguinal region	2	0	1	0
Skin in another region	0	0	1	1
Spine, with paraplegia	0	0	1	0
Chest wall, pleura, and ribs (not lungs)	0	0	1	0
Rib	0	0	0	1

METASTASES

Most patients who die of fibrosarcoma have metastases to the lungs; however, fibrosarcomata may metastasize to numerous other areas.

Table II lists the metastases demonstrated in the thirty-five patients seen prior to 1948. In six of these patients, abdominal metastases developed, and in one patient with a lesion of the lower extremity a metastasis to the scalp, proved by biopsy, later developed. In two of the patients seen since 1948, metastases to the lungs have developed, and another had metastases to lymph nodes at the time of surgery.

Occasionally, the tumor does not metastasize but continues as a locally invasive lesion. Pack and Ariel reported one case with the original lesion on the dorsum of the hand. During a period of twenty-one years, this lesion extended up the extremity and into the chest wall and neck. One patient in our series had a lesion in the arm which extended into the neck during a four-year period of time. When last examined, shortly before he expired, there was still no demonstrable metastasis to his lungs. A patient with this type of lesion obviously has an excellent chance for cure if the locally involved tissue is removed completely.

Metastases to lymph nodes by fibrosarcoma are relatively rare. In our series, metastases to lymph nodes were proved in only three cases (6.7 per cent.). Two of these patients had Grade 3 and one had Grade 4 lesions. This rate of involvement is comparable to that recorded by other authors.

TABLE III

LOCAL RECURRENCE OF FIBROSARCOMA OF THE EXTREMITIES
(FORTY-FOUR PATIENTS * WITH FIFTY-TWO LOCAL RECURRENCES)

No. of Local Recurrences†	Grade 1	Grade 2	Grade 3	Grade 4
None	7	6	3	4
1	3	2	2	3
2	2	2	1	2
3	2	0	0	1
4	1	0	1	0
5	0	0	0	1
6	1	0	0	0
—	—	—	—	—
Total	23	6	8	15

* Not including the one patient who refused treatment.

† Following all treatment, including treatment prior to and after being seen at the Clinic.

TABLE IV

RELATIONSHIP OF THE SURVIVAL RATE TO THE LOCATION OF FIBROSARCOMA OF THE EXTREMITIES IN THIRTY-FIVE CASES

Location of Lesion	No. of Patients Living Less than Five Years	No. of Patients Living More than Five Years	Five-Year Survival Rate (*Per cent.*)
Upper Extremity			54
Hand	1	3	
Forearm	0	0	
Arm	5	4	
Lower Extremity			68
Foot	0	1	
Leg	2	1	
Thigh	5	13	

RECURRENCES

Fibrosarcoma is noted for its tendency to recur following excision. Of the patients in our series, 54.5 per cent. had local recurrences at some time during the course of their disease. Stout reported a recurrence rate of 60 per cent., and Pack and Ariel reported a rate of 56 per cent. Table III shows the number of recurrences following surgical treatment in our series (based on forty-four cases, since one patient refused therapy). This high recurrence rate indicates that often all of the diseased tissue is not removed. There was no statistical difference between the type of treatment or grade of malignancy and the length of time before recurrence. The time from operation to local recurrence varied from one month to five years and eleven months, with an average of approximately ten months.

SURVIVAL STATISTICS

For our series, survival statistics were computed upon the thirty-five cases observed prior to 1948. Four of six patients over sixty years of age expired in less than five years. This might indicate that the older age group carried a poorer prognosis; however, this number is too small to be significant. Also, this observation is at variance with the report by Pack and Ariel in which the extreme age groups, both young and old, seemed to afford a slightly better prognosis. Again the number was too small to be significant. It may be that age is really no factor in prognosis.

In agreement with Pack and Ariel, we noted a better prognosis for female patients, for whom we were able to report a rate of 72 per cent. of five-year-cures as compared with

TABLE V

RELATIONSHIP OF TUMOR GRADE TO SURVIVAL IN THIRTY-FIVE CASES OF FIBROSARCOMA OF THE EXTREMITIES

Grade of Tumor	Survival				Five-Year Cure Rate (*Per cent.*)
	0–2 Years	2–5 Years	5–10 Years	10 Years or Longer	
Grade 1	2	2	3	6	69
Grade 2	3	1	3	2	56
Grade 3	1	2	3	1	57
Grade 4	2	0	3	1	67

TABLE VI

RELATIONSHIP OF TREATMENT TO SURVIVAL IN THIRTY-FIVE CASES OF FIBROSARCOMA OF THE EXTREMITIES

Treatment	Survival				Five-Year Cure Rate (*Per cent.*)
	0–2 Years	2–5 Years	5–10 Years	10 Years or More	
Local excision	0	0	6	3	100.0
Local excision and roentgen therapy	3	2	2	6	61.0
Amputation	5	2	4	1	41.7
Amputation and roentgen therapy	0	1	0	0	0.0

a 53 per cent. rate for the males. This difference may be significant, but the reason for such a difference remains obscure.

Meyerding and his coworkers and Stout noted a slightly poorer prognosis for patients with lesions of the lower extremity. Pack and Ariel, on the other hand, reported a better prognosis for patients with fibrosarcoma of the lower extremities. In our series, 54 per cent. of the patients with lesions of the upper extremity and 68 per cent. of the patients with lesions of the lower extremity had five-year cures (Table IV). When the information of these several series is considered, one must admit again that there probably is no real significant difference in prognosis according to this criterion. Thus, it seems that age, sex, and location of the tumor have no real bearing on prognosis.

There are two remaining factors to be considered. They are the degree of neoplasia of the tumor and the type of treatment employed. Most authors agree that for fibrosarcoma, as with other tumors, the more anaplastic the growth, the poorer the prognosis. Our results did not corroborate this fact fully, as Grade 4 lesions were few in number and the results of treatment were satisfactory (Table V). In the two series from the Mayo Clinic, there was a difference of over 30 per cent. in the cure rates for patients with Grade 1 and Grade 4 lesions. Stout noted a 46.3 per cent. difference between the cure rate for lesions with good differentiation and the rate for those with poor differentiation. Pack and Ariel state that in their series, in each instance of high-grade malignancy, the patient's course was characterized by early and widespread metastases and, usually, by rapid death.

TREATMENT

The survival statistics in our series do not demonstrate adequately the efficacy of the various forms of treatment (Table VI). They do illustrate, however, that local excision can be successful, although it is often followed by local recurrence. Radical treatment (amputation) was reserved for the more difficult cases (after the tumor had recurred several times, or when the tumor had extended into the axilla or inguinal region, or in instances of large Grade 3 or Grade 4 lesions); and results must be evaluated with this in mind. If more amputations had been performed for the lower-grade and more distally located lesions, the cure rate probably would have been much better; but, obviously, many limbs would have been sacrificed needlessly.

Roentgen therapy alone was not used for a proved fibrosarcoma. In one patient, however, a mass recurred, two years after local excision, at the site of a previous fibrosarcoma. No biopsy was done of the recurrent mass, but it was assumed to be a recurrent fibrosarcoma and roentgen therapy was employed. The mass regressed, and, after eight years,

the patient is alive and apparently free from disease. Most authors agree that irradiation is of doubtful value in the treatment of fibrosarcoma. When surgery is not feasible, however, the patient should have the benefit of roentgen therapy; and, occasionally, a patient will be cured by this means. Stout reports three cases and Pack and Ariel report one case in which the patients were cured by roentgen therapy. In far advanced cases, irradiation may be employed for palliation.

Five-year-survival rates, reported by various authors, vary widely (most of the survival rates range between 30 and 50 per cent.). Meyerding and his coworkers reported that only 27.1 per cent. of their patients survived for three or more years after surgery, while Pack and Ariel reported a five-year-survival rate of 81.3 per cent. With these reports, our five-year-survival rate of 63 per cent. compares favorably.

Still, there are many patients who die of fibrosarcoma. If the percentage of cures is to be increased, treatment (the one controllable factor which affects the course of the disease) must be improved. Fibrosarcoma generally affords ample opportunity for treatment, as the duration of symptoms is usually long, and, even after repeated excisions, the tumor often remains a local disease for many months or even years. The fact that the many local excisions performed by physicians everywhere are repeatedly inadequate seems to indicate that often all of the diseased or abnormal tissue is not being removed. Dupuytren's contracture of the plantar or palmar fascia would be an analogous situation. We know that the simple removal of the nodule, or nodules, in the plantar or palmar fascia does not cure this disease; it is necessary to remove the entire fascial layer. Perhaps the same theory of treatment would produce better results for fibrosarcoma. Instead of only the tumor mass being removed, the mass with a wide area of the surrounding fibrous tissue should be removed — not because the tumor mass extends into this tissue, but because this tissue possibly has the same capability of and predisposition for malignant change.

The development in the occasional patient of multiple, apparently separate fibrosarcomata occurring in the same region lends credence to such a theory. Pack and Ariel reported one such case. Two cases in our series were very interesting in this respect; both patients had primary lesions on the medial aspect of the thigh. In both patients, following removal of the primary lesions, similar lesions subsequently developed on the same aspect of the affected thigh, but distal to the original tumors. The five-year-survival rate of 81.3 per cent. following therapy at the Memorial Hospital (reported by Pack and Ariel) may be due to their radical local excision of the tumor and adjacent tissues.

Unless there is excellent opportunity for radical local excision of the tumor and adjacent tissues, primary amputations should be performed for patients with lesions of high-grade malignancy, and the amputation site should be located high above the area of tumor involvement. Also, should the lesion recur even after radical removal of the tumor mass and adjacent fibrous tissue (including muscle tissue when the tumor is apparently arising or involving intermuscular or muscular connective tissue), amputation should be done. If, however, the initial local excision is radical enough, more lives and more limbs may be saved.

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ONE-STAGE PLASTER CORRECTION OF SCOLIOSIS FOLLOWING SPINE FUSION

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Many methods have been devised for the corrective treatment of scoliosis. A committee for the study of scoliosis, appointed by The American Orthopaedic Association in 1941, investigated 425 cases of scoliosis in sixteen clinics in this country. This committee concluded that treatment by the hinged-turnbuckle cast of Risser, which was used in 80 per cent. of the cases studied, was the most effective and popular method of treatment of scoliosis at that time.

Since that time, other methods for the correction of scoliosis have included the use of the Milwaukee brace of Blount and Schmidt, the transection jacket of von Lackum, the hammock-suspension cast of LeMesurier, the lateral-pressure frame with arm and leg traction of Thomas, the lateral-traction jacket of Kleinberg, and other casts or braces of definite value.

The method to be described here consists in a one-stage traction cast applied approximately two weeks after surgical spine fusion. Prior to the use of this cast, we had employed the hinged-turnbuckle type of corrective cast and had encountered many difficulties with it. In addition to encountering difficulties, we were not satisfied that the desired amount of correction of the scoliotic curve was being obtained or adequately maintained by the Risser jacket. A review of our cases in 1948 revealed that the degree of correction we were obtaining did not compare favorably with the average of 53 per cent. correction in severe cases obtained at the larger scoliotic centers, as reported by the Research Committee of The American Orthopaedic Association. Our results obtained by applying a traction cast after spine fusion have been considerably better and are essentially the same as those reported with the use of the Risser jacket elsewhere. We feel that there are many very definite advantages to this method. The practice of applying corrective casts following spine fusion in scoliosis has been a great aid to the patient, the anaesthetist, and the orthopaedist. Full credit is due to Dr. A. R. Shands, Jr., for suggesting the idea. This idea was suggested to us when we were visiting the Alfred I. duPont de Nemours Crippled Children's Hospital in Wilmington, Delaware; Dr. Shands stated further that they were using a traction-type cast and contemplated the postoperative application of the corrective cast in one stage. Stimulated by his suggestions and ideas, we have developed a one-stage traction-type cast which is applied approximately two weeks following the operative spine fusion.

From our experience to date, we feel that the traction-cast method of correction of scoliosis has many very definite advantages over the method using the wedged, hinged cast; and, in addition, the correction of the spinal curvature has been more effective in our hands with the traction cast than with the wedged-type cast previously used.

The disadvantages of the method using the wedged, hinged jacket, as they appear to us, are as follows:

1. The cast is difficult to apply and is excessively heavy and thick.
2. Proper wedging of the cast, following application of the hinges and turnbuckles, is laborious for the orthopaedist and uncomfortable for the patient.
3. There is a tendency for this type of cast to increase the secondary curves.
4. Corrective forces are brought about by the cast's pressure through the soft tissues.
5. The anaesthetist's difficulties in maintaining an adequate airway during surgery are often very great.

FIG. 1

Artist's drawing showing patient ready for application of directional traction forces.

6. Proper sterile draping for surgery through the thick cast window is annoying and awkward.

7. The time necessary for applying the cast, wedging it, and obtaining correction prior to surgery has, in our hands, been an average period of three to four weeks.

8. The cast is uncomfortable for the patient in the long postoperative immobilization period.

9. The thick cast, with hinges and turnbuckles included, makes it most difficult to obtain satisfactory roentgenograms for proper measurements of the curves.

10. The extreme lateral bending for six months after wedging in this type of cast is a very poor functional position, and such immobilization defies that basic orthopaedic principle that casts should be applied in a functional position.

The advantages of the method using the traction-type cast are as follows:

1. The amount of correction we have obtained by the traction-cast method has been considerably greater than that obtained by the method using the wedged, hinged cast.

2. There is safety of anaesthetization in operating when the patient is not in a heavy cast.

3. The traction cast may be applied more easily than the wedged, hinged cast.

4. This type of cast does not tend to accentuate the secondary curve.

5. The corrective forces are not applied through the cast. By this method, the correction is obtained first, and the cast is applied to hold the corrected position.

6. There is a greater degree of comfort for the patient in the long period following fusion.

7. With this type of cast, the patient is immobilized with the shoulders parallel to the iliac crests, a functional position.

8. There is greater ease of nursing care in the immediate postoperative period and also in the long period of immobilization following application of the cast.

9. By applying the corrective traction and cast after surgery, there is the added advantage that much of the tightness of the soft tissues about the involved area of the spinal curve has been released.

DESCRIPTION OF APPLICATION OF CAST

This method of treatment of scoliosis utilizes the fundamental principles of treatment as advocated by Cobb, Risser, von Lackum, Ferguson, and many others. We use the

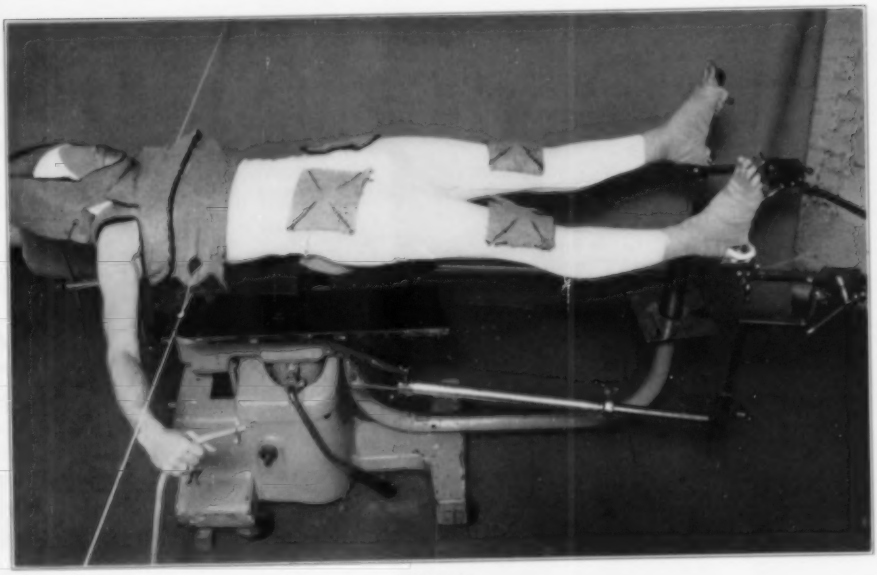

FIG. 2

Photograph of patient on orthopaedic table with directional traction forces applied and ready for application of cast.

modified Hibbs type of spine fusion and cover the fusion area with a large amount of homogenous cancellous bone-bank bone. Approximately two weeks after operation, while the fusion area is still pliable, the skin sutures are removed and moderate sedation is administered to the patient. We use the Albee-Comper fracture table for application of the traction-type cast, but any type of fracture table with facilities for cephalad-caudad traction would be satisfactory.

The patient is first covered with stockinette from head to foot, and then is placed on the orthopaedic table, resting on the sacral rest, cervical yoke, and head rest. (We have also used a single strip of muslin or canvas to support the trunk but prefer the sacral rest and cervical yoke.) *The peroneal post must not be used in applying this type of cast.* The head halter is prepared from a piece of felt, five inches wide and approximately thirty inches long, which is split longitudinally in the middle for a distance of twelve inches in order to afford a proper fit over the mandible and occiput. The ends of this strip of felt are attached to a fixed object at the head of the table, thus stabilizing the head and neck. Both feet are placed on the foot rests and firmly fixed with muslin. With the head halter firmly fixed, caudal traction is slowly applied by turning the rachets on the foot rests a few notches at a time. This can be done easily while the plaster and other equipment are being prepared. We have found that this caudal traction should be rather strong, so that the cast will maintain effective traction on the spine.

A strip of felt, five inches wide, is placed around the trunk, with the *center directly over the apex of the primary curve.* Another strip of felt of the same width is fitted over the shoulder *opposite* the apex of the primary curve (Fig. 1). These strips of felt are attached to individual ropes suspended over pulleys to which is attached from ten to thirty pounds of weight, depending upon the size of the patient and the severity of the curve. The traction applied to the felt strips over the apex of the primary curve and over the shoulder opposite the apex of the primary curve combines with the cephalad-caudad traction to correct the curvature of the spine, including both the primary and secondary curves. If a strip of felt is used over the pelvis while the combined traction is applied, it will help

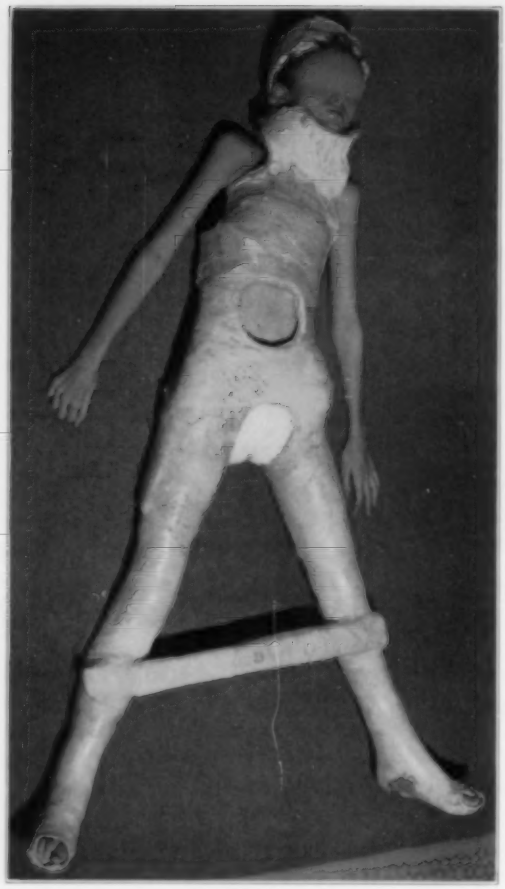

FIG. 3

Photograph of a patient in a completed cast.

to balance the patient on the table.

When the proper amount of correction has been obtained, felt pads are placed over all areas where pressure might be exerted, such as the iliac crests, the shoulders, feet, and heels. The plaster is then applied; the entire head is encased as in a helmet, and the trunk, the entire lower extremity and foot on one side, and the extremity down to the knee on the opposite side are covered. After the plaster has hardened, all traction is removed. The felt strips have been left in place in order to provide additional padding in the pressure areas. The leg and foot of the extremity which is on the high side of the pelvic tilt should be included in the cast. From a practical standpoint, incorporation of both legs and feet in the cast is not uncomfortable to the patient (Fig. 3).

In the past two years, we have treated by this method thirteen patients following operation for scoliosis. Ten of the patients had idiopathic scoliosis, two had scoliosis secondary to poliomyelitis, and one had possible neurofibromatosis. Our results are shown in Table I.

DISCUSSION

All of the patients in this study had curvature of a severe degree; the average measurement of the primary curve was 80.9 degrees, the greatest curve measuring 109 degrees, the smallest curve 58 degrees. The average measurement of the curves immediately after correction in traction casts was 37 degrees, and the average amount of correction at that time was 43.9 degrees.

In Table I are shown the measurements before and after correction as well as the amount of correction obtained in the individual cases. In addition, the measurements made at the end of six months and eighteen months are reported. All of these patients were maintained in the traction-type cast for a minimal period of six months following surgery. We feel that the immobilization period of six months is perhaps insufficient for some of the most severe cases of scoliosis, and at present we contemplate immobilizing these patients for a longer period of time.

We agree with Butte that in some cases the application of a corrective cast may be necessary before operation, in order to determine the exact level of fusion. In a few instances, we applied a wedging-type corrective plaster cast before surgery, in order to accurately determine the level of fusion. The cast was then removed, and the fusion was carried out; the traction-type cast was applied two weeks after surgery.

In some of our early cases, we wedged the cast several days after application, in

TABLE I

MEASUREMENT OF PRIMARY SCOLIOTIC CURVE IN ELEVEN PATIENTS BEFORE, DURING, AND AFTER TREATMENT *

Patient	Type of Scoliosis	Measurement of Primary Curve Before Correction (*Degrees*)	Measurement of Primary Curve After Correction (*Degrees*)	Amount of Correction Obtained (*Degrees*)	Measurement of Primary Curve Six Months after Operation (*Degrees*)	Measurement of Primary Curve Eighteen Months after Operation (*Degrees*)
L. E.	From neuro-fibromatosis	79	31	48	40	44
H. S.	Poliomyelitic	80	38	42	57	70
G. B.	Congenital idiopathic	83	19	64 †	Unknown	Unknown
J. C.	Idiopathic	88	35	53	57	65
J. M.	Idiopathic	58	12	46	35	52
D. R.	Idiopathic	81	42	39	40	51
S. F.	Idiopathic	92	62	30	62	63
P. M.	Idiopathic	73	35	38	37	48
S. B.	Idiopathic	74	37	37	42	52
M. C.	Idiopathic	109	56	53	72	74
D. P.	Idiopathic	73	40	33	45	62

* Two patients have not been included in this table as they are still in the postoperative cast and have not been followed long enough to be included in this report.

† This patient did not undergo surgery; correction was obtained by traction only and maintained by the traction cast. The cast was removed after four months at the parents' insistence, and the patient did not return for follow-up. In this case of scoliosis, the curve was a very flexible one, and this was responsible for the remarkable amount of initial correction. The end results are not known.

order to obtain greater correction. We had been somewhat timid in applying sufficient traction in the earlier cases and feel that had more traction been used, the wedging would not have been necessary. We have not found it necessary to wedge any cast in the past year. We feel that wedging this type of cast does not distract at all from its advantages. The cast can be wedged with ease and without disturbing the functional orthopaedic position of the patient whose shoulders are maintained in a position almost parallel to the iliac crests.

As can be seen from Table I, the amount of correction of the primary curve at the time of removal of the cast (six months after operation) has not been maintained at the eighteen-month follow-up period in all cases. This loss of correction seems to be the result of too early removal of the immobilizing cast, which permitted the improperly matured fusion mass to bend as ambulation was resumed. Undoubtedly pseudarthrosis was present in some areas of the fusion mass in some of the cases. We do not believe, however, that either of these two factors contra-indicates the use of the traction type of cast. Our relative inexperience in performing spine fusions for scoliosis has not permitted us to attain the degree of proficiency in effecting solid fusions which has been demonstrated in the larger scoliotic centers. In light of more recent knowledge of the types of scoliosis, we now feel that some of the patients with idiopathic scoliosis in the series probably should not have been subjected to surgical correction.

From our experiences to date, we feel that this method of correction of scoliosis has many definite advantages over the previously used method of correction with the wedged, hinged cast. We offer it for consideration by other orthopaedic surgeons in the hope that this report will stimulate others to utilize the traction-cast method and to report their experiences.

The authors are indebted to Miss Dorothy Booth, Medical Artist, Medical College of Virginia, for the illustration accompanying this article.

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DISCUSSION

Clinical Evaluation of Freeze-Dried Bone Grafts

(*Continued from page 596*)

I believe, however, that before we can utilize such techniques generally—especially when dealing with massive transfers—we must learn more about the fate of homogenous bone. It is well recognized that homogenous bone does not behave as does autogenous bone following transfer. This fact must be kept in mind even though good clinical results are obtained following the use of various forms of homogenous bone.

Capt. Carr (closing): I think the comments and discussion have been stimulating and well put; as usual this opens a veritable Pandora's box of speculation. Dr. Wilson's interest in bone banks and a thorough study of his papers had stimulated my thinking on the subject. All of this helped to convince me when I arrived at Bethesda that the experimental evidence developed there, at that time, supported a clinical trial of the freeze-dried grafting material.

For the first few months, in fact the first year or two, we selected our cases carefully as we wanted every possible chance of success. We do not do this any more; we use freeze-dried grafts routinely. This, of course, implies an understanding of the uses and limitations of any form of bone grafts. Our primary responsibility as surgeons is to promote healing; it is not the testing of any particular "brand" of grafting material.

In regard to Dr. Ray's excellent analysis, let me say that we do not pretend to know all of the factors responsible for the success of these grafts. Personally, I am not a biochemist or a physicist, but there is an excellent team of these working with us. I do not know which label to put on the mechanism of healing; it seems to me that the theory of "induction", elaborated by Urist[a], offers a suitable explanation of this point. From research laboratories, such as Dr. Ray's and Dr. Herndon's eventually will come further knowledge of this mechanism and the reasons for it, or we will have to develop better grafting material. At this time, we can recommend freeze-dried homogenous bone as a useful tool.

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Proceedings

AMERICAN SOCIETY FOR SURGERY OF THE HAND

The Tenth Annual Meeting of the American Society for Surgery of the Hand was held in Los Angeles under the presidency of Dr. Joseph H. Boyes of Los Angeles.

The Clinical Session of the Society was held on January 26, 1955, at the Orthopaedic Hospital, 2400 South Flower Street, Los Angeles. At the morning session, patients were presented by members of the staffs of the Orthopaedic Hospital and other hospitals in the Los Angeles area.

Dr. Charles Leroy Lowman [1] presented cases of residual paralysis following poliomyelitis and illustrated the importance of stability in scapular motions, which in one case was provided by an interscapular fascial transplant. Abdominal fascial transplantations were discussed as an aid in improving posture and gait.

Dr. Alvia Brockway [2], Chief of Staff at the Orthopaedic Hospital, presented two cases of residual paralysis from poliomyelitis. In one case in which the deltoid was absent and good scapular muscles had been retained, the short head of the biceps and the long head of the triceps had been transplanted to the acromion; the patient had a good range of abduction. In one patient with good scapular control and a flail upper arm, a shoulder fusion had been performed. Discussion was carried on as to the optimum position for fusion, Dr. Brockway recommending less abduction and internal rotation than is usually advised in the textbooks.

Dr. Carl Nemethi [3] presented problems of primary care of injured hands. In punch-press and other injuries which involved loss of a portion of the proximal or middle segment of the finger, he had been able to save the good tactile end of the finger by recessing the phalanx and bringing about fusion of the phalanges at the time of the primary repair. Although the fingers were short, a good range of motion was retained in the proximal joints and the tactile pulp was retained for better sensation [a]. In another patient who had lost the proximal interphalangeal joint as the result of an avulsion injury but yet retained normal flexor tendons and digital nerves, an immediate replacement prosthesis—namely, a miniature strap hinge made of stainless steel—had been inserted, connecting the proximal and middle phalanges. An excellent range of flexion was present, but the extensor tendon had not yet been reconstructed. Three months had elapsed since operation. There was good union of the bone to the intramedullary peg of the hinge, and pain and tenderness were absent.

a. Nemethi, C. E.: The Primary Repair of Traumatic Digital Skeletal Losses by Phalangeal Recession. J. Bone and Joint Surg., **37-A**: 78–88, Jan. 1955.

Dr. G. Wilbur Westin [4], Chief of Shriners' Hospital for Crippled Children, presented patients with flail upper extremities which had been fitted with Robin's Aids prostheses. With this apparatus, which works by means of a cable passed over the shoulder and down the back to the foot, the patient is enabled to flex the flail elbow and thus bring the hand to the face. One patient, having worn the splint for several months, demonstrated marked ability to use the splint for flexion of the elbow.

Dr. Vernon L. Nickel [5] presented patients from the Rancho los Amigos Hospital for poliomyelitis. He stated that at this Hospital there were approximately one hundred patients in respirators at the present time and noted that the mortality from bulbospinal poliomyelitis in Los Angeles had been reduced to 12 per cent., whereas formerly it had been from 50 to 60 per cent. A patient was presented in a wheel chair who by means of balanced slings on the arm and an external appliance was able to use his hand to shave, to write, and to hold small articles. This patient also demonstrated "frog" breathing, a method by which patients literally swallow air and are thus enabled to live outside the respirator for periods extending over several hours. Another patient demonstrated excellent motion following a transfer of the extensor carpi radialis longus into the tendons of the flexor digitorum profundus.

Dr. Robert Mazet, Jr.[6], demonstrated patients with biceps cineplasties and forearm prostheses.

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[3] 5592 Santa Fe Avenue, Los Angeles, California.
[4] 1930 Wilshire Boulevard, Los Angeles, California.
[5] 1216 Wilshire Boulevard, Los Angeles, California.
[6] U. S. Veterans Hospital, Los Angeles, California.

One, an elevator worker, forty-four years old, who had had an amputation just below the elbow, was able to lift approximately eighty-five pounds, but he used the hook rather than a cosmetic hand when he worked. A ten-year-old boy with a biceps cineplasty done for congenital amputation in the upper forearm showed a lesser range of activity in the biceps but demonstrated remarkable agility with the hook, even though the prosthesis had been in place for only five days.

Dr. George V. Webster [7] then presented cases of nerve injury and repair, illustrating the better results from repair in the younger age group. He demonstrated a patient with ulnar-nerve paralysis whose final recovery did not take place until a secondary neurolysis was performed. During the interim, however, the patient had received galvanic stimulation which was thought to have kept up the bulk of the muscle and to have improved the result. An interesting discussion then followed, and the consensus was that galvanic stimulation had not yet been proved to alter the results following nerve repair.

Dr. Walter C. Graham [8] presented two case reports, illustrated with motion pictures. The first involved a complete joint transplantation performed four years ago. In this case a metatarsophalangeal joint with its epiphysis was transplanted to the first metacarpophalangeal joint in a young boy. This was done after an abdominal flap had been applied and was followed by a free graft of the extensor pollicis longus tendon. An excellent result was demonstrated. In the second case, a tendon graft was used to prolong the extensor carpi radialis longus to the first interosseus, traversing the dorsum of the hand in the subcutaneous tissues. This homologous graft had been kept in a deep freeze at 10 degrees below zero Fahrenheit for eighteen months before being used. Excellent function was obtained; the graft could be seen in the subcutaneous tissues.

Luncheon was served in the Memorial Library of the Hospital, followed by a guided tour of the new Rehabilitation Center.

In the afternoon session, Dr. James N. Wilson [9] first presented cases of nerve injury to the upper extremity. A patient with a lesion of the posterior interosseous nerve following a fractured radius was shown after repair of the nerve. All muscle function had returned except for that of the extensor proprius of the index finger. An eighteen-month-old child was presented, with congenital absence of the flexor tendons of the little finger. Two cases of electrical burns were presented; one of these was a patient with severe deformity of both hands and with loss of median-nerve and ulnar-nerve function and of all flexor tendons at the wrist level. It was felt by many present that amputation of one hand should be done and the patient should be furnished with a utility hook, and that, on the hand showing the lesser injury, an attempt should be made to restore to him the basic functions of sensation and pinch. The second patient had had bilateral electrical burns of the forearms in 1946. After a series of operations, with delayed repair of the median and ulnar nerves by means of bulb sutures, sensation had returned, and the patient was able to return to his work.

A patient was presented with limitation of motion in the index finger; at operation, a diffuse pearly-gray thickening of the flexor tendon sheath had been found.

Dr. L. D. Howard [10] discussed rheumatoid tenosynovitis, as compared with tuberculous tenosynovitis. In this particular case, microscopic examination had shown no specific lesion. The use of compound F as a local injection was suggested.

A congenitally deformed hand in which there was a bifid little finger and no thumb was then presented. One of the rays of the little finger with its intact epiphysis had been passed as a free transplant to the thumb. X-ray examination eight months after operation showed apparent growth of the bone, although in discussion Dr. Sterling Bunnell [11] felt that good bony contact with the adjoining metacarpal had not been established and that this was an essential point in the transfer of any digit.

A two-year-old child with a cavernous hemangioma of the index finger was then shown. The lesion extended into the palm, and considerable discussion ensued as to the future treatment. Arteriograms were suggested. Dr. Raymond Curtis [12] felt that an arteriovenous shunt might later develop. He suggested excision and replacement with a skin graft if necessary. Dr. Arthur J. Barsky [13] thought that amputation of the ray might be indicated.

Two brothers, aged four years and four months respectively, were then presented with congenitally flexed thumbs. This was the topic of a paper to be presented by Dr. Elden C. Weckesser [14] at the Scientific Sessions on Friday, January 28. He felt that continued splinting of the thumbs in extension should be carried out for a period of six months.

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[8] 1421 State Street, Santa Barbara, California.
[9] 1401 South Hope Street, Los Angeles, California.
[10] 516 Sutter Street, San Francisco 2, California.
[11] 516 Sutter Street, San Francisco 2, California.
[12] 2919 St. Paul Street, Baltimore 18, Maryland.
[13] 174 East 72nd Street, New York 21, N. Y.
[14] 10465 Carnegie Avenue, Cleveland 6, Ohio.

Another congenital anomaly, palmar flexion of the wrist, was shown in a two-year-old patient who had crawled on the sharply flexed wrist. Here again it was felt that splinting in the corrected position was indicated before any radical treatment was considered.

A ten-year-old girl with a spastic hemiplegia was shown; in this case the brachioradialis had been transplanted to the dorsiflexors of the wrist and all the digital flexor tendons had been tenodesed into the radius after division from the muscles. The patient showed a good range of automatic flexion of the fingers.

A similar procedure had been carried out on a man, fifty-five years old, with residual poliomyelitic paralysis of both upper extremities. In this case a good active dorsiflexor of the wrist had remained, but all flexor muscles were paralyzed. Because it was necessary to use this hand for propulsion of a wheel chair by holding the rim, only the profundi of the middle, ring, and little fingers were tenodesed to the radius. The pronator teres, prolonged by a graft, had been inserted into the index finger and the brachioradialis had been transferred into the flexor of the thumb. These procedures had given him a good strong pinch and enabled him to manipulate the wheel chair.

Dr. Joseph H. Boyes [15] then presented a series of cases, the first a fourteen-year-old girl with a thickened flexor tendon sheath of the right middle finger which had persisted for four years. It was thought to be a tuberculous tenosynovitis and excisional biopsy was recommended. The remaining patients were presented in groups, the first group with lesions of the nerves of the upper extremity, showing the effects of late repair or reconstruction. A boy with radial-nerve and ulnar-nerve injuries resulting from laceration of the nerves in the axilla was shown. Recovery of wrist and digital extensors took place, even though the nerve repair had been done four years after injury. Later the intrinsic-muscle paralysis was relieved by the Bunnell-type of sublimis transfer. A man, twenty-two years old, who had had an avulsion of the upper trunk of the brachial plexus was shown; recovery of the muscles followed direct excision of four centimeters of the neuromatous thickening of the trunk, and suture. A seventeen-year-old boy was shown with excellent recovery of the ulnar nerve, including the intrinsic muscles, following a two-stage repair. At the time of the primary injury a single suture had been inserted in the nerve, the damage having taken place in the middle of the upper arm. A secondary repair, done approximately six weeks later, was followed by recovery within eighteen months. An eighteen-year-old girl with a median-nerve injury in the forearm following Volkmann's ischaemia had recovered sensation after a bulb suture of the median nerve and a formal repair after the nerve had been lengthened. A nine-year-old boy with a brachial plexus palsy, resulting in loss of function of all the flexor muscles, was shown. A transplantation of the biceps tendon into the profundi of the fingers had been done, the lacertus fibrosus being utilized as a pulley mechanism and the biceps being prolonged with a free tendon graft into the profundus tendons of the forearm. Excellent range of motion had returned, with marked power of flexion when the elbow was extended.

Several cases of paralysis following poliomyelitis were shown, and the types of transfers possible in these patients were discussed. In restoring flexion to the paralyzed digits, when the wrist dorsiflexors are present, utilization of the automatic flexion mechanism was considered preferable to transferring a wrist extensor, and thus weakening the power of the wrist. Dr. Daniel C. Riordan [16] suggested that, if only one of the wrist extensors remained, tenodesis of the flexors should be performed. It was the consensus that fusion of the wrist, especially in children, should be done only as a last resort and that all attempts should be made to gain motion, especially flexion, by tenodesis operations. One man, aged thirty-two, was shown who had had poliomyelitis at the age of five, resulting in loss of the thenar musculature. An atrophic thumb with subluxation of the metacarpotrapezial joint had been present. A tendon transfer of the Bunnell opponens type had been performed, enabling him to pinch. In one patient the only muscle available to provide the power of opposition was the extensor carpi ulnaris. This was prolonged by free tendon graft around the ulnar border of the forearm to cross the thenar eminence into the dorsal and ulnar aspect of the proximal segment of the thumb. Two patients were shown to illustrate the effect of tenodesis for paralyis of the dorsiflexors of the wrist and fingers.

Patients in whom tendon grafts had been done as two-stage procedures were shown. It was emphasized that, in many patients with scarred fingers and particularly flexion contractures, a preliminary operation should be done to excise the deep cicatrix and to relieve the scar by Z-plasty if necessary. In both patients shown it also had been necessary to reconstruct the pulley mechanisms by circumferential tendon grafts in the middle and proximal segments of the fingers. Illustrating the possibility of a tendon-grafting procedure even after many years, one patient was shown in whom a full-length tendon graft had been placed in the finger six years after injury and another, twenty-three years after injury.

Congenital deformities were shown in two patients. Four patients with arthrogryposis in various stages were shown. In one, both hands had sharp flexion of the metacarpophalangeal joints and some webbing of the thumb. Operation on the right hand had been done, deepening the clefts and applying split-skin grafts to the flexor surfaces. On the opposite hand steady prolonged stretching over a period of many years, accentuated by the patient's learning to play the Hawaiian steel guitar, had resulted in full extension of the fingers. Two patients were shown with arthrogryposis with completely extended elbows and absent

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biceps muscles. In one, the Clark operation, transplanting a portion of the pectoralis major, had been performed on the right arm, and the triceps had been transplanted to replace the biceps on the left. The pectoralis transplant could be felt to function, but the muscle was extremely weak. In both of these patients, considerable difficulty had been encountered in mobilizing the elbow prior to operation; and in one, it had been necessary to do a lengthening of the triceps as well as excision of some of the collateral ligaments of the elbow joint. A girl with congenital absence of the forearm and hand was shown; the loose redundant skin over the small stump of the ulna and radius had been freed from the underlying bone and held away by means of an internal cagelike splint of Kirschner wire. It was proposed in a second stage to insert a metatarsal bone with its intact epiphysis into this stump of ulna and thus to provide a longer forearm stump before contemplating a prosthetic arm. An excellent biceps muscle was present which later could provide power for cineplasty.

Two patients with bilateral congenital absence of the radius were shown. In one case preliminary soft-tissue correction had been accomplished and the arm was temporarily immobilized by transfixion Kirschner wire. In the other patient, one arm had been corrected by soft-tissue surgery, followed by transplantation of the upper portion of the fibula with its epiphysis to take the place of the radius. This patient also showed symptoms of Fanconi's syndrome,—that is, an aplastic anaemia which carries with it a poor prognosis. A four-year-old child who had suffered extensive burns of the back of the hand and fingers was shown; for loss of extensor apparatus over the middle joints, criss-cross tendon grafts from the toe extensors had been inserted and attached to the sublimis tendons in the palm. A full range of motion was present, in spite of the fact that the method of insertion of the grafts was deliberately varied in all four fingers.

Three patients with Volkmann's contracture were presented. In all there had been evidence of considerable nerve damage. In one the median, ulnar, and radial nerves had been paralyzed, and recovery followed neurolysis soon after the onset of disability. In the other two, repair of the median nerve had been accomplished by bulb suture, followed by formal repair when lengthening had occurred. Both of these patients had then had some flexion restored to the fingers by tenodesing flexor tendons to the radius and utilizing the power of the dorsiflexors of the wrist. One, a young woman, was able to hold the bow of a violin between the thumb and the tips of the fingers after the tenodesis. In the other, a college student, the pinch was restored by rerouting the long extensor tendon of the thumb from the dorsum of the hand to the volar surface where it was prolonged with a graft and attached to the active pronator teres muscle.

A patient with scleroderma was shown who had knuckle pads and thickened bands of fascia in the palm, resembling those seen in Dupuytren's contracture. Biopsy of the palmar fascia had been performed, with the report of normal findings on histological examination.

A general discussion of problems in surgery of the hand was initiated by Dr. William H. Frackelton [17], who asked about the type of treatment suitable for injury to a digit in which the skin had been avulsed by a ring. Dr. Darrel Shaw [18] reported two patients in whom an immediate single-pedicle tubed graft was applied to the finger. He felt that this was considerably better than burying the stripped finger beneath the abdominal fat. There was also some discussion as to the use of paratenon surrounding flexor tendon grafts. Dr. Frackelton suggested a long transverse incision in the wrist, enabling one to obtain paratenon without causing the ugly scar of the longitudinal incision. Dr. Boyes said that, in similar cases done with and without paratenon, the results were so close that the paratenon did not appear to be an essential feature. Dr. Bunnell cautioned against making too many pulleys in the fingers and thus causing too much scar and friction.

Arranged by Dr. Walter C. Graham and the other members of the Program Committee, the Scientific Sessions of the meeting, held on January 28, 1955, at the Hotel Biltmore, were of exceptional interest. Summaries of the presentations follow:

Tumors of the Hand. Dr. Joseph L. Posch [19] presented an inclusive summary of the diagnosis and treatment of tumors of the hand. It was beautifully illustrated by photographs of tumors selected from the author's series of 147 lesions. The tumors considered were benign, premalignant, and malignant lesions of epithelial origin, tumors arising from connective tissue including fibromata, lipomata, and ganglia, as well as giant-cell and glomus tumors, epidermoid cysts, pyogenic and foreign-body granulomata, aneurysms, and several bone tumors.

Of particular interest was his presentation of a carcinoma of the nail bed in a patient who had had a chronic paronychia for one and a half years. Amputation, followed by epitrochlear and axillary lymph-node dissection, was recommended as treatment. A similar procedure was used for a melanosarcoma of the nail bed. A rare case of chondrosarcoma of the proximal phalanx of the long finger was treated by amputation of the finger and excision of the metacarpal.

Dr. Michael L. Mason [20] stressed that, although carcinomata arising from x-ray dermatitis metastasize late and are of low-grade malignancy, once they start to invade, they become highly malignant. He also

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[20] 154 East Erie Street, Chicago 11, Illinois.

commented on the small synovial cysts about the distal interphalangeal joints and base of the nail which were not mentioned by the author. He considered that they arise from the deeper layer of the corium and that they can be eradicated only by complete excision, including the overlying skin, followed by the application of skin grafts.

Dr. L. D. Howard [10] distinguished between pseudoganglia, which are associated with degenerative arthritis, and true ganglia. In treating the former he had had good results after injecting compound F and immobilizing the part; while with the latter, this form of therapy was unsuccessful. He also mentioned that two cases of synovial sarcoma in the hand had been reported, although these were not mentioned by the author. With regard to carcinoma of the nail bed, he pointed out that erosion of the distal phalanx was a constant finding.

Tuberculosis of the Hand. Dr. Philip H. Moore [21] presented a report on twenty patients diagnosed clinically as having tuberculosis of the hand or wrist or both. In twelve, the diagnosis was proved by biopsy. He called attention to the possibility of cold as a predisposing etiological factor. Although the incidence of pulmonary tuberculosis is the same in Eskimos and Indians, fifteen of these patients were Eskimos who were constantly being exposed to extremes of temperature, while only five were Indians. There was only one case of tuberculous synovitis without associated bone involvement. In all, three fingers were amputated; in two cases the lesions had healed without treatment, while the other patients were treated by a medical regimen with or without surgical excision of diseased tissue. Dr. Moore recommended a prolonged treatment by streptomycin with either isoniazid or para-aminosalicylic acid. He advocated drug administration for at least ninety days with continuation of treatment after sinus closure for an additional period equal to one-half the time required for sinus closure. The length of treatment actually employed ranged from fifteen to 180 days, with an average of about ninety days. All patients obtained useful hands with varying amounts of scarring and deformity. The author concluded that, with early diagnosis and prompt adequate medical treatment, amputations, arthrodeses, and plastic procedures should not be necessary.

Dr. David M. Bosworth [22], in his discussion of Dr. Moore's paper, stressed that these bone changes, as seen by x-ray, as well as the synovitis seen clinically in these cases, could be caused by mixed infections rather than by tuberculosis. He feels that it is absolutely necessary to prove the diagnosis either by biopsy or by culture of the tubercle bacillus. He prefers to use a single antibiotic drug, rather than multiple drugs, since in this way one can determine better which drug is effective. Furthermore, in the event that toxic symptoms develop while the patient is on multiple drug therapy, it is difficult to determine which drug is responsible, if several have been used.

Dr. Ernest M. Burgess [23] emphasized the decrease in incidence and mortality of tuberculosis in the State of Washington in the past ten years. He feels that the disease is not the same problem now that it was ten years ago.

Providing Automatic Grasp by Flexor Tenodesis. Dr. James N. Wilson [9] reported four patients with severely paralyzed hands, the function of which was salvaged, in part at least, by providing automatic grasp by means of a tenodesis of the flexor tendons, combined with appropriate tendon transplants when this was feasible. Active wrist extension of adequate range and power is a prerequisite of this procedure which consists in (1) tenodesis of the flexor profundus tendons and long flexor of the thumb to the radius under sufficient tension so that on complete wrist extension the finger tips touch the palm and (2) tenodesis of the proximal end of an opponens transplant to the distal end of the ulna to provide opposition by the use of the short extensor tendon. In the absence of wrist extensors, the brachioradialis was transplanted to the tendon of the extensor carpi radialis brevis. With adequate wrist extensors, the brachioradialis was employed to enhance pinch, being transferred to the tendon of the long thumb flexor distal to the tenodesis in two cases, while the pronator teres was put into the profundus tendon of the index finger by means of a free graft, in addition, in order to provide voluntary flexion of this digit. The author pointed out that, when the brachioradialis was used as a wrist extensor, it lost power with the elbow in the position of flexion, since it crosses this joint. Hence, when the hand was brought to the mouth, the grasp weakened. Similarly, with weakness of the triceps, the grasp mechanism was inadequate unless the elbow was held in extension with the other hand. The author stressed in particular that arthrodesis of the wrist is often contra-indicated in cases of this type.

Dr. Daniel C. Riordan [16] re-emphasized the importance of not doing a wrist fusion until this procedure had been attempted, and indicated that arthrodesis of the metacarpophalangeal joint of the thumb may be of value.

Dr. Donald R. Pratt [24] stressed the importance of careful planning in procedures of this sort, in order to select the one which promises the greatest return of function.

Congenital Subluxation of the Thumb into the Palm. Dr. Elden C. Weckesser [14] presented five cases of congenital subluxation of the metacarpophalangeal joint of the thumb. All were bilateral except for one

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patient with congenital absence of the left thumb. All showed an abnormal mobility of the metacarpophalangeal joint with no active extension before treatment and the thumb firmly clasped beneath the flexed fingers. In three there was an associated tightness of the thumb web space. The author suggested that in this condition the clasp of the fingers upon the thumb in early infancy is greater than normal, possibly as the result of finger flexion contractures, as seen in three of the patients, or as the result of the impaired mobility of the metacarpophalangeal joint of the thumb which permitted the fingers to keep it constantly within their grasp. In the three patients seen from one to three months after birth, plaster immobilization of the thumb in the extended position for from one to seven and a half months gave excellent results, with active extension of the thumb. The casts were changed at four-week to six-week intervals to accommodate for growth. In one patient seen at two years of age, a fair to good result followed three months' immobilization, while in a patient, first treated at nine years of age by fusion of the metacarpophalangeal joint, the result was fair. In two cases plastic procedures to the contracted thumb web space were necessary in addition to the other measures. The author emphasized the importance of early plaster immobilization as the best form of therapy.

Dr. George S. Phalen [25] suggested that four of the author's cases might be considered arthrogryposis but indicated that the ease and permanency of correction was not consistent with this condition. He raised a question concerning the part played by the soft-tissue bands in the first web space in the production of this deformity.

Dr. Arthur J. Barsky [13] described four cases with similar thumb deformities, as well as other contractures, due to arthrogryposis congenita.

Vasomotor Reactivity in Dupuytren's Contracture. Dr. F. X. Paletta [26] reported his clinical studies of fifteen cases of Dupuytren's contracture in which the vasomotor reactivity of the skin was measured by means of a photo-electric plethysmograph. The fifteen patients studied represented early cases, moderately advanced cases, and late cases, as well as patients with no involvement. There was found to be a progressive decrease in the vasomotor response as the disease increased in its severity, with a return to normal reactivity after surgery had been performed. The initial response to surgery appeared as early as two weeks after the operation. The author pointed out that the clinical evidence suggested that Dupuytren's contracture may be related to a disturbance in the function of the autonomic nervous system in the hand.

In the discussion which followed, Dr. George V. Webster [7] complimented the author on an interesting and ingenious study. While realizing that the etiology of this condition is unknown, he feels that there is a close correlation between vascular changes and the Dupuytren's contracture in individuals with some predisposition to this condition. He pointed out that Dupuytren's contracture had been known to develop following an aneurysm of the axillary artery with pressure on the surrounding structures, and also he pointed out the hereditary factors involved in the disease.

Dr. Julian M. Bruner [27] felt that the data was interesting; on the other hand, he felt that it was difficult to be certain whether or not the decrease in vasomotor response which was found in these patients before operation might not have been due simply to the fixation of the small vessels by the disease, and the improvement after fasciectomy being due to the perivascular sympathectomy, in effect, performed at the time of surgery. He felt that more observation and study would be necessary.

Surgery of Rheumatic Hands. Dr. Sterling Bunnell [11] presented a report on reconstructive hand surgery to restore function to the "burned out" rheumatoid arthritic hand. The author first discussed flexion deformity of the metacarpophalangeal joints. In those cases in which it is possible to passively reduce the deformity of the metacarpophalangeal joint, he recommended that the metacarpal be shortened by resecting a portion of its base. However, in those cases in which one is unable, preoperatively, to passively reduce the deformed metacarpophalangeal joints, he recommended an arthroplasty, with resection of the head of the metacarpal. For the ulnar drift of the fingers, he recommended shifting the insertion of the long extensor tendon to the radial side of the extensor hood at the metacarpophalangeal joint and, if necessary, tenotomizing the lateral bands where contracture of the interosseus muscles had occurred. The author stressed the need for a careful analysis of all of the anatomical and pathological factors which were involved in producing the deformity and correcting these on the basis of one's analysis.

Dr. Arthur Steindler[28], in his discussion, emphasized the need for early non-rigid splinting to prevent deformity, and felt that one should be certain that there would be an improvement in function after surgery before resorting to extensive surgery in this clinical entity.

Dr. S. Benjamin Fowler [29] pointed out that, in those patients in whom there was a flexion deformity of the fingers at the proximal interphalangeal joint, extension could be improved by a division of the flexor tendon sheath and a removal of the sublimis tendons.

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[29] 1921 Broadway, Nashville 4, Tennessee.

Volkmann's Contracture. Dr. J. Leonard Goldner [30] had analyzed twelve cases of Volkmann's contracture seen in the past five years. In six of these patients the contracture had followed supracondylar fractures, which were reduced and held in acute flexion; two followed operation for muscle hernia of the forearm; and four were due to massive trauma of the forearm. These patients were seen from three weeks to twelve years after injury. The author recommended decompression of the median nerve early if signs of compression of the nerve persisted after the first four to six weeks with no improvement. He particularly emphasized the role played by the pronator teres in this compression. He pointed out the need for a decompression of the median nerve when its course lies either through or beneath the pronator teres. He suggested early tenotomy and lengthening of the flexor tendons of the fingers and wrist as treatment for the contracted muscles. In addition, a resection of the proximal and distal rows of carpal bones was recommended as a means of obtaining length to the contracted flexor muscles. Tendon transfers were recommended for loss of function of the intrinsic muscles.

Dr. Benjamin S. Fowler [29], in his discussion, stated that he would not be adverse to lengthening the wrist flexors early, but felt that one should use non-rigid splinting to see how much the finger flexion contracture could be overcome conservatively before lengthening these flexor tendons. He does not favor carpectomy, but prefers in certain cases to shorten the radius and ulna to gain length of the flexor tendons, thus leaving the flexion and extension of the wrist to provide greater range of motion, both for extension of the fingers and for grasp when the flexor muscles would act in a tenodesis effect.

Dr. James C. Bateman [31], in his discussion, presented slides of several cases to point out his conclusion that in Volkmann's contracture the median and ulnar nerves are damaged over an extensive area in the forearm, particularly at the level of the muscle bellies of the flexor tendons where the extensive muscle damage is seen in this clinical entity.

Congenital Absence of the Radius. Dr. Daniel C. Riordan [16] carefully reviewed the various etiological factors which have been presented as the cause of this clinical entity, and the previous techniques which have been used to correct the condition. His treatment has been carried out in a series of nine patients, of whom only six were reported, for one had died from aplastic anaemia and two were not included because of the lack of sufficiently long follow-up. He overcame the skin contracture and the acute angulation at the wrist by very early splinting or plaster immobilization, so as to gradually place the hand in a normal position, overcoming the tightness on the radial aspect. The splinting is begun as soon as possible after birth. The next stage is that of a surgical release and the placement of the carpus over the ulna. Later, the ulna may be osteotomized to correct bowing and lastly a fibular transplant is done as a final stage, the intact epiphysis with a portion of the proximal part of the fibula being removed. This is fused to the ulna and positioned so as to stabilize the wrist. The author was unable to demonstrate growth of the epiphysis, but the epiphysis did mature and close. There was no functional abnormality in the knee or ankle joint as a result of the removal of the upper end of the fibula and no apparent growth disturbance in the donor leg.

Dr. Sterling Bunnell [11] did not feel it likely that the transplanted epiphysis of the fibula would grow. He showed several cases where a Z-plasty had been performed on the concave side, with a release of the deep fascia and capsular ligaments of the wrist and a lengthening of any tight wrist tendons, in order to position the carpus over the ulna. He pointed out that, as a rule, it is necessary to do a dissection on both radial and ulnar sides of the wrist in order to shift the ulna to the radial position. He complimented Dr. Riordan on his presentation, but pointed out that the patients might need a wrist arthrodesis at a later date despite the excellent treatment received while they were children.

Dr. Joseph H. Boyes [15] spoke of the complication of aplastic anaemia in one of his patients who had congenital absence of the radius.

Adduction Contracture of Thumb. Dr. J. Edward Flynn [32] discussed the etiological factors in adduction contractures of the thumb, together with the pathological findings. The author stressed the need for prevention by proper hand splinting and he outlined the methods of correction of this deformity by excision of the scar and removal of the paralyzed first interosseus and short adductor muscle, with application of skin grafts or pedicle skin flaps by the abdominal-tube method to give the added skin coverage after widening the thumb cleft. He recommended tendon transfers to provide opposition when necessary. When stabilization of the thumb seems more desirable, this may be done by bone graft between the thumb and index metacarpals.

Dr. Raymond M. Curtis [12], in discussion, complimented Dr. Flynn on his presentation and operative results. He pointed out the need for preserving the active first interosseus and short adductor muscles by subperiosteally stripping the latter from the metacarpal and allowing it to be reinserted, while the short adductor tendon, after detachment, was reinserted at a lower level on the thumb metacarpal. He also discussed use of a direct skin-flap shift from the dorsum of the hand for coverage of the adductor space, with skin graft to the dorsum of the hand as a method of providing additional skin coverage when the cleft was widened.

[30] Duke Hospital, Division of Orthopaedics, Durham, North Carolina.
[31] Christie Street Hospital, Toronto 4, Canada.
[32] 475 Commonwealth Avenue, Boston, Massachusetts.

DR. BENJAMIN S. FOWLER [23] pointed out the need in some patients for a fusion of the metacarpophalangeal joint of the thumb, in addition to the bone strut between the metacarpals. In some instances, he has seen a subluxation at the carpometacarpal joint when this joint has not been fused, but only the bone strut has been used.

At the Executive Session of the Society held on Saturday, January 29, Dr. S. Benjamin Fowler was inducted into office as President for the coming year, and the following officers were elected:

President-Elect: L. D. Howard, M.D., San Francisco, California;
Vice-President: J. Edward Flynn, M.D., Boston, Massachusetts;
Secretary-Treasurer: George V. Webster, M.D., Los Angeles, California;
Historian: Julian M. Bruner, M.D., Des Moines, Iowa.

The following three surgeons were elected as Members of the Society:

Robert Clifford, M.D., Detroit, Michigan;
H. Minor Nichols, M.D., Portland, Oregon;
James N. Wilson, M.D., Los Angeles, California.

The next Annual Meeting of the American Society for Surgery of the Hand will be held at the Palmer House, Chicago, on Friday, January 27, 1956.

ORTHOPAEDIC RESEARCH SOCIETY

The First Annual Meeting of the Orthopaedic Research Society was held at the Hotel Statler, Los Angeles, California, Saturday, January 29, 1955, with Dr. Paul C. Colonna presiding. The first Scientific Session of the Society was attended by seventy-four members and guests.

At the Executive Session held on Saturday afternoon, January 29, a revised Constitution and By-Laws was adopted. It is to be noted that the objective of the Society is to "encourage research by orthopaedic surgeons". An Advisory Council under the chairmanship of Dr. Arthur Steindler was elected. This Council will serve in an advisory capacity to those interested in orthopaedic research, regardless of whether or not they are members of the Society. Members are to be elected upon recommendation of a Membership Committee. Applicants for membership should be sponsored by two members of the Society; but, as it is anticipated that some investigators may not be acquainted with members of the Society, the Membership Committee has the authority to accept applications direct from those interested in becoming members. Application forms may be obtained from the Secretary, Charles H. Herndon, M.D., 2065 Adelbert Road, Cleveland 6, Ohio.

The following officers were elected:
President: J. Albert Key, M.D., St. Louis, Missouri;
President-Elect: Philip D. Wilson, M.D., New York, N. Y.;
Secretary-Treasurer: Charles H. Herndon, M.D., Cleveland, Ohio;
Member-at-Large to Serve on the Executive Committee: Robert D. Ray, M.D., Seattle, Washington.

The next meeting of the Society will be held at the Palmer House, Chicago, Illinois, on January 28, 1956.

Abstracts of papers presented at the Scientific Session follow:

The Use of Intramedullary Pressures in the Early Determination of Aseptic Necrosis in the Femoral Head. DR. JAMES S. MILES [1] had studied the intramedullary pressure of the femoral heads of over thirty patients by means of the introduction of needles into the femoral head and the attaching of these needles to various manometers. Special manometers were used to record the pressures in several instances; but, under ordinary circumstances, the needles were attached to spinal-fluid manometers. The needles were introduced into normal femoral heads, as well as femoral heads after reduction of dislocation of the hip. The needles were also introduced proximal to femoral-neck fractures and intertrochanteric fractures.

Wide variation in the pressures within the femoral heads was observed. These pressures were as high as forty to fifty centimeters of saline. More important than the measurement of pressure was the presence or absence of fluctuations within the manometers. These fluctuations corresponded exactly to the arterial-pulse pressure and rate. The pressure and fluctuations were not affected by the various types of anaesthesia utilized.

A number of the patients had been followed sufficiently long to make possible the correlation of the presence or absence of these fluctuations with the subsequent roentgenographic appearance of the femoral

[1] 4100 East 9th Avenue, Denver 7, Colorado.

head. In several patients with active fluctuations, subsequent roentgenograms demonstrated viability of the femoral head; in several other patients without fluctuations, subsequent roentgenograms demonstrated necrosis of the femoral head. The method is being extensively studied in the hope that it may be of prognostic importance.

Experimental Studies Regarding the Possible Use of Self-Curing Acrylic in Orthopaedic Surgery. Dr. L. L. Wiltse [2] and Dr. R. H. Hall [3] had experimented with self-curing methyl methacrylate for approximately three and a half years to determine what uses it might have in orthopaedic surgery. Methyl methacrylate, an acrylic plastic, has been used for many years in medicine and, especially, in dentistry. The clear plastic used in the Judet prosthesis is methyl methacrylate. It has been known for many years that this clear material could be obtained by mixing a white powder, polymere, with a colorless liquid, monomere, and by adding heat. However, it was not until sometime between 1936 and 1941 that a German chemist found that, by adding a very small amount of a catalyst and an accelerator to the powder and the liquid, the material could be made to set without the addition of heat. The catalyst used in the powder is benzoyl peroxide and the accelerator in the liquid is a tertiary amine. This material is called self-curing or cold-curing methyl methacrylate.

Tests have been made in order to determine whether there is tissue reaction when the material is put into tissue while in the soft stage and is allowed to set. Vitallium was used as a standard for comparison, and sections were made from muscle and from bone which had been in contact with the material for as long as a year. Both rabbits and monkeys had been used in these tests. It was found that there is no more reaction to this acrylic than to Vitallium. Large masses of the soft material had been put into the tissues of rabbits and had been allowed to set. The liver, kidneys, and lungs from these animals were studied to see whether there had been deleterious effects. No deleterious effects were noted, even when masses of plastic in the creamy state, large enough to correspond to two pounds in the human being, had been injected into muscle and fascial planes.

From the standpoint of strength, this material is slightly less strong than the regular acrylic.

A practical system of sterilizing both the powder and the liquid had been developed.

As regards possible uses, the authors believe it might be used in building up metallic prostheses to fit more snugly in bone, in filling bone cavities, in making prostheses for replacing portions of joints, and in filling cranial-vault defects or defects in the bones of the face.

The authors concluded that self-curing methyl methacrylate causes no more tissue reaction than does Vitallium in the monkey or rabbit. It can be obtained sterile and can be molded in about ten minutes. The heat of polymerization is the most troublesome and limiting factor to its use.

Studies in Bone Transplants. Dr. M. Bonfiglio [4] and Dr. W. S. Jeter [5] had compared the repair capacity of various types of bone transplants. With the use of fresh autogenous transplants in fractures, union was prompt and relatively little inflammatory response was seen; whereas, with the use of fresh homogenous transplants in fractures, healing was delayed and was relatively poor. An intense inflammatory reaction to homogenous transplants was noted. Fibrous-tissue replacement of the fresh homograft was common. Homogenous frozen transplants produced little osteogenic stimulus, and fractures in which these had been used did not usually unite. The use of a second homogenous fresh transplant from the same donor caused an increased inflammatory reaction as compared with that caused by the primary homograft.

Techniques had been developed for extracting substances from bone. Immunological reactions to the extracts following homogenous transplantation were checked. Other animals had been intensively immunized; following this, histological and immunological studies were carried out. These studies showed that extracts of homogenous bone are antigenic and that homografts used in previously immunized animals show a less intense inflammatory reaction. These studies were designed to determine the effect of time relationship on inflammatory response and the repair capacity of the transplant.

The Effect of the Thyroid Gland on Methylcholanthrene-Induced Soft-Tissue Tumors and the Attempted Experimental Induction of Benign and Malignant Chordomata. Dr. H. O. Marsh [6], Dr. W. P. Callahan, Jr. [7], and Dr. R. F. Looker [8] presented a preliminary report of experimental work being carried out to determine the possible hormonal influence of the thyroid hormones upon methylcholanthrene-induced sarcomata (fibrosarcomata, osteosarcomata, and liposarcomata) in guinea pigs and reported an attempt to produce benign or malignant chordomata in rabbits and guinea pigs. In the first part of the experiment, three groups of guinea pigs had been used: (1) A control group of twenty-seven guinea pigs had been injected with forty milligrams of methylcholanthrene; (2) thirty guinea pigs had received forty milligrams of methylcholanthrene

[2] 117 East Eighth Street, Long Beach 13, California.
[3] Veterans Administration Hospital, Long Beach, California.
[4] State University of Iowa, Iowa City, Iowa.
[5] State University of Iowa, Iowa City, Iowa.
[6] 3244 East Douglas, Wichita, Kansas.
[7] Wichita, Kansas.
[8] Wichita, Kansas.

and twenty-five milligrams of crude thyroid extract daily; and (3) thirty guinea pigs had received forty milligrams of methylcholanthrene and fifty milligrams of propylthiouracil daily. In ten of the control animals (71.4 per cent.) which survived more than three months, sarcomata developed. The average time of appearance of these tumors was three and a half months. In the second group, the stimulation of the thyroid gland, which resulted from the administration of the crude thyroid extract, apparently enhanced the toxigenicity of the metabolic products of methylcholanthrene. A high mortality rate was experienced in this group of animals during the second or third week after injection, and only one animal survived more than three months. In the third group, the physiological blocking of the thyroid gland indicated, but did not prove, that, with propylthiouracil, the carcinogenicity of methylcholanthrene was enhanced. In thirteen of the guinea pigs (81.6 per cent.) which survived in this group, sarcomata developed at two and one-half months.

The nucleus pulposus of the intervertebral disc in six control rabbits had been traumatized in an unsuccessful attempt to produce benign chordoma. The nucleus pulposus of the intervertebral discs in seventeen experimental animals had been traumatized and the carcinogenic agent, methylcholanthrene, had been implanted by various methods. Proliferation of the notochordal tissue, either benign or malignant, could not be stimulated.

The Use of Frozen Stored Tendons for Grafting. An Experimental Study. Dr. Walter C. Graham [9], Dr. Dean A. Smith [10], and Dr. Matthew P. McGuire [11] presented a report on the use of frozen autogenous tendon grafts in rabbits. The tendons had been secured from rabbits being sacrificed for other reasons, and they had been placed in a deep freeze, without any special care, for approximately three months. The tendons had then been transplanted to replace the tendo achillis in adult healthy rabbits.

The animals were sacrificed from forty-two to 105 days for examination of the grafts. At the time the examination was made the grafts had apparently been completely replaced by living normal tendon tissue. Fourteen grafting procedures had been carried out, and only one of these failed. The other thirteen transplants functioned normally at the time the animals were sacrificed.

It was concluded that frozen autogenous tendon could be used to replace the tendo achillis in healthy adult rabbits.

Histological Study of Treated and Untreated Cases of Osteoporosis in Humans. Dr. Jack Levine [12], Dr. Leo Gitman [13], and Dr. Herman Bolker [14] pointed out that there have been no studies of the histological changes in bone in cases of osteoporosis in human patients following the usual form of therapy with estrogens and androgens. Roentgenographic criteria for the diagnosis of this condition have not been established. A technique for performing bone biopsies with a Turkel bone-biopsy needle was described. The bone was taken from the iliac crest before and after treatment. After one month of treatment with one milligram of estradiol given intramuscularly three times weekly, no changes in the appearance of the bone histologically or by x-ray could be demonstrated, although there had been clinical improvement in the patient's condition. This study will be pursued, and increased doses of hormones will be used in order to note whether histological changes can be obtained. Methods for standardization of the roentgenographic criteria for the diagnosis of osteoporosis will be sought.

Papers presented by title only:

1. Intraneural Injection, Sciatic Nerve, for Anaesthesia by Lt. Col. R. W. Augustine, Maxwell Air Force Base Hospital, Montgomery, Alabama.
2. Heterogenous Bone Grafts, Experimental Study in Rabbits by Lt. Col. R. W. Augustine, Maxwell Air Force Base Hospital, Montgomery, Alabama.
3. An Anatomical Study of the Posterior Primary Division and the Sino-Vertebral Nerves of the Lumbar Nerves by Herbert E. Pedersen, M.D., Ernest Gardner, M.D., and Conrad Bluncк, M.D., Detroit, Michigan.
4. Use of Irradiated Bone as a Grafting Material by Jonathan Cohen, M.D., Boston, Massachusetts.
5. Changes of Mesodermal Structures Induced with Certain Aminonitriles by I. V. Ponseti, M.D., S. Wawzonek, M.D., R. S. Shepard, M.D., and C. Y. Chang, M.D., Iowa City, Iowa.
6. Experiments in Bone Growth and Repair by Robert S. Siffert, M.D., New York, N. Y.
7. Femoral Torsion and Its Relation to Gait by Lawrence Crane, M.D., Portland, Maine.
8. Hydrocortone in Joint Surgery by Leonard F. Bush, M.D., Danville, Pennsylvania.
9. Scapulocostal Syndrome by Arthur A. Michele, M.D., Brooklyn, New York.
10. Stress Tolerance in Bone and Metal by Carl D. Martz, M.D., Indianapolis, Indiana.
11. The Experimental Use of Freeze-Dried Arteries for Tendon Sheaths by Lt., j.g., D. R. Koth and Lt., j.g., W. H. Sewell, Bethesda, Maryland.

[9] 1421 State Street, Santa Barbara, California.
[10] New Orleans, Louisiana.
[11] Salinas, California.
[12] 20 Plaza Street, Brooklyn 17, New York.
[13] Brooklyn, New York.
[14] Brooklyn, New York.

12. A Method of Treatment for the Fixed Adolescent Round-Back by Herman S. Lieberman, M.D., Beverly Hills, California.
13. Growth in Transplanted Bone by Charles F. Thompson, M.D., and Edward V. Schaffer, M.D., Indianapolis, Indiana.
14. Electromyography and Electrodiagnosis in Patients with Congenital Club-Foot by Caiser F. Orofino, M.D., and James Golseth, M.D., Los Angeles, California.
15. The Orthopaedic Aspects in a Metabolic Study of Acromegaly by James A. Nicholas, M.D., and Philip D. Wilson, M.D., New York, N. Y.
16. The Experimental Effects of Intramedullary Nails in Growing Bones by Frederick Lee Liebolt, M.D., New York, N. Y.
17. A Study of Experimental Trauma to the Distal Femoral Epiphysis in Rabbits by J. Albert Key, M.D., and Lee T. Ford, M.D., St. Louis, Missouri.
18. The Effect of Whole-Body Irradiation on the Healing of Fractures Treated by Intramedullary Nailing by Col. Ernest A. Brav, Washington, D. C.
19. Calcium Content of Rarified Bone by Alexander Lichtor, M.D., Leonard Walker, Ph.D., and Joseph Lichtor, M.D., Kansas City, Missouri.
20. Elbow Arthroplasties in Monkeys by R. H. Hall, M.D., and L. L. Wiltse, M.D., Long Beach, California.
21. A Study of the Immobilization of Joints in Rats by G. W. N. Eggers, M.D., and E. Burke Evans, M.D., Galveston, Texas.
22. Further Experiments with Muscle-Pedicle Bone Grafts by Joel Hartley, M.D., New York, N. Y.
23. Acetabular Reconstruction in Arthroplasty of the Hip by Duncan C. McKeever, M.D., Houston, Texas.

ORTHOPAEDIC RESEARCH SOCIETY

CONSTITUTION

Article I. Name

The name of the Society shall be the Orthopaedic Research Society.

Article II. Purpose

The purpose of the Society shall be to encourage research by orthopaedic surgeons.

Article III. Membership

1. There shall be two classes of membership,—namely, Senior and Active. Senior Members shall consist of the sponsoring members over fifty years of age and such other additional qualified persons over fifty years of age who may be elected from time to time.

a. Qualification for Senior Membership shall be previous scientific accomplishments and performance in orthopaedic surgery or related fields and interest in the training and development of young orthopaedic surgeons. In addition, when any Active Member reaches the age of fifty, he will be automatically transferred to the Senior Group.

b. The Senior Members shall have the rights and privileges of Active Members during the initial phase of the Society's formation and shall participate in the conduct of the Society until the Active Members number forty, whereupon they shall have no vote and they shall be ineligible to hold office except on the Advisory Council.

c. When the Active Members number forty, Senior Members will be exempt from the payment of dues.

2. Active Members shall consist of orthopaedic surgeons or other investigators who have been elected to the Society on the basis of previous scientific activity and continued participation in the field of research. An Active Member who reaches the age of fifty automatically becomes a Senior Member.

Article IV. Officers

The officers of the Society shall consist of a President, President-Elect, and Treasurer-Secretary. Election shall be held each year at the Annual Meeting.

1. The President shall preside at all meetings of the Society and at the meetings of the Executive Committee, and shall exercise the usual duties of the Office of President. He shall serve for a period of one year, and thereafter as a member of the Executive Committee for a term of two years.

2. The President-Elect shall serve one year *ex officio* as a member of the Executive Committee in order to familiarize himself with the affairs of the Society. At the conclusion of the next Annual Meeting following his election, he shall be inducted into the Office of President. The President-Elect will serve in the capacity

of Vice-President and as such shall preside in the absence of the President. In the event of resignation, incapacity, or death of the President, he shall automatically succeed to the vacant office.

3. The Secretary-Treasurer shall, as Secretary, keep the minutes of the meetings of the Society and of the Executive Committee. He shall conduct the official correspondence of the Society and carry on the usual duties of a secretary. As part of this duty, he shall report at the Annual Meeting concerning all the business done by the Society, either at its Annual Meeting or at the meetings of the Executive Committee.

As the Treasurer, he shall assume custody of all funds of the Society and shall collect all dues and other contributions from the members, and shall pay all bills which are properly chargeable to the Society. He shall make a report at the Annual Meeting of the state of the Society's financial affairs and such report will be properly audited. The Secretary-Treasurer shall be reimbursed for the expenses of his office and he will be eligible for re-election.

Article V. The Advisory Council

1. There shall be an Advisory Council composed of five elected Senior Members. At the first Annual Meeting five members shall be elected for the following terms: one for one year, one for two years, one for three years, one for four years, and one for five years. Thereafter, one new member shall be elected at each Annual Meeting and shall serve for a term of five years.

2. The member who is senior from the standpoint of service on the Committee shall serve as Chairman.

3. An interim vacancy shall be filled by the election of another Senior Member at the next succeeding Annual Meeting. That member will fill the unexpired term.

4. The Advisory Council shall serve the following functions:

a. The Advisory Council should be prepared to advise any investigator concerning problems encountered in research.

b. The Advisory Council shall be prepared to make recommendations to the Orthopaedic Research Foundation and similar organizations regarding the support of specific research projects.

c. The Advisory Council should be available for consultation with the Executive Committee.

Article VI. The Executive Committee

1. There shall be an Executive Committee which shall be composed of the President, President-Elect, Treasurer-Secretary, Chairman of the Advisory Council, the two Past-Presidents who have last retired from the Office of President, and one member elected at large at the Annual Meeting.

2. The Executive Committee shall transact the necessary business of the Society during the times when the latter is not in session. It shall have the authority to act in the name of the Society.

Article VII. Election to Membership

1. There shall be a Membership Committee composed of five Active Members who shall be elected at the Annual Meeting. At the first Annual Meeting the five members of the committee shall be elected for the following terms: one for one year, one for two years, one for three years, one for four years, and one for five years. Thereafter, one new member shall be elected at each Annual Meeting and shall serve for a term of five years. An interim vacancy shall be filled at the next succeeding Annual Meeting by the election of another Active Member to fill the unexpired term.

2. Applications for membership must be sponsored and seconded by a member of the Society. It will be the duty of the Membership Committee to review the applications and to make specific recommendations to the membership. It is recognized that, under some circumstances, there may be applications for membership submitted to the Membership Committee with no sponsor. Action on those applications will be left to the discretion of the Membership Committee who will have the authority to process those applications in a fashion similar to those made in the usual manner.

3. One month prior to the Annual Meeting, the Secretary shall send all members a list of proposed candidates. The Membership Committee shall announce the new members at the last Executive Session of the Annual Meeting.

4. Membership is automatically forfeited by an Active Member if he

a. fails to attend three consecutive meetings without suitable excuse, or

b. if for five consecutive years he fails to submit to the Program Committee a subject for presentation.

Article VIII. Meetings

1. There shall be an annual meeting of the Society, the site and time of which shall be designated by the Executive Committee and ordinarily announced at the last Executive Session of the preceding Annual Meeting. The program shall consist of a Scientific Session at which reports of research are presented by the members and invited guests and an Executive Session at which the business of the Society is transacted. Only the members and invited guests shall have the privilege of the floor.

2. Guests may be invited by members provided the Secretary is notified prior to the meeting. The number of guests may be limited at the discretion of the Executive Committee.

3. The program shall be developed by the Executive Committee. The Secretary shall solicit each member at least six months prior to the Annual Meeting for titles and accompanying abstracts of papers which he will be prepared to report to the Society at this Annual Meeting.

Article IX. Elections

Elections of Officers shall be by ballot and shall be held at the final Executive Session at the Annual Meeting. Nominations for Officers and Members of such committees as may be required shall be presented by a Nominating Committee of three, the Chairman of which shall be appointed by the President, and the two other members shall be elected at the first Executive Session of the Annual Meeting. Other nominations for Officers and Members of Standing Committees may be made from the floor.

Article X. Dues

Active Members shall pay annual dues of $10.00 which are payable upon demand of the Treasurer. A registration fee at Annual Meetings may be required of members and active guests at the discretion of the Executive Committee.

Article XI

This Constitution may be amended by two-thirds affirmative vote of the members present and voting at any Annual Meeting. Only those proposals for amendment shall be considered which have been submitted to the Secretary-Treasurer in writing, signed by two Active Members, one month in advance of the Annual Meeting.

Article XII

The proceedings of this Society and the duties of the Officers where not specifically designated shall be governed by *Robert's Rules of Order*.

Article XIII

A quorum of the Society shall be one-third of the Active Members.

Approved, January 29, 1955.

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS SCIENTIFIC SESSIONS

January 29 to February 3, 1955

Summaries of the papers presented at the Scientific Sessions follow:

Low-Back Pain. Dr. Rex L. Diveley [1], Dr. Richard H. Kiene [2], and Dr. Paul W. Meyer [3] reported a follow-up study of 3,587 patients with low-back pain treated during a twenty-five-year period. All were private or compensation patients. Of these, 1,516 patients had been followed for three or more years. Nineteen diagnostic categories were considered, the most important of which were lumbosacral strain with congenital anomalies (1,108 patients), arthritis (542 patients), lumbosacral strain with negative roentgenographic findings (495 patients), postural backache (478 patients), sacro-iliac strain or sprain (271 patients), and tight or contracted fascia lata (148 patients). The methods and results of treatment, both conservative and operative, were reviewed in general terms. Fasciotomies were performed on 252 patients with complete or definite relief in 83 per cent. Treatment of lumbosacral strain (735 patients), of protruded intervertebral discs (42 patients), of sacro-iliac strain (89 patients), of arthritis of the sacro-iliac joint (45 patients), of arthritis of the spine (112 patients), and of postural backache (180 patients) resulted in improvement or relief of symptoms in approximately 90 per cent. of the patients. However, in patients with arthritis of either the spine or the sacro-iliac joints, therapy was somewhat less effective.

The authors noted (1) that, in general, results from surgical treatment in this series were better than the results of conservative therapy, (2) that patients who had had the combined operation of disc excision and spine fusion did better than those who had had simple excision, (3) that surgical treatment was less satisfactory in compensation and liability patients than in the other patients, (4) that early purposeful treatment of lumbosacral strain gave better results than did delayed treatment, (5) and that patients with arthritis of the spine were seldom completely relieved by conservative measures—they were, however, improved. Fasciotomy, in the authors' experience, had proved to be of great assistance in the treatment of arthritis of the spine.

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[2] 4312 J. C. Nichols Parkway, Kansas City 2, Missouri.
[3] 4312 J. C. Nichols Parkway, Kansas City 2, Missouri.

Dr. Alexander P. Aitken [4] had not been able to approach Dr. Diveley's success with lumbosacral fusion of 86 per cent.; the same was true in a nation-wide survey of compensation cases treated by fusion. His experience with industrial-accident backache had included a high proportion of patients in whom the diagnosis was disc injury. In these the result of surgical exploration had proved to be negative. He emphatically agreed with Dr. Diveley that patients with acute low-back symptoms should be hospitalized and not be allowed to be ambulatory.

Dr. J. Albert Key [5] commented on the authors' diagnostic classification, stating that, in his opinion, about 90 per cent. of the cases of idiopathic low-back pain, with or without sciatica, are caused by disc lesions, as against the 2.3 per cent. ruptured discs in the series reported. He also noted that spondylolisthesis had not been included, that all cases of arthritis had been grouped together with no differentiation between the rheumatoid type and the degenerative type, that the reported results of conservative treatment were nearly uniform, and that the results of operative treatment did not show differences which were of statistical significance. Treatment, whether operative or conservative, immobilizes the low back, makes the patient comfortable, and gives the lesion, regardless of its origin, a chance to heal, especially if therapy is begun early. Finally, he emphasized the influence of psychological factors and the economic status of the patient on the course and results of treatment.

Chondrosarcoma of the Proximal End of the Femur Treated by Resection and Bone Replacement—A Five-Year Result. Dr. Vernon P. Thompson [6] and Capt. Clair T. Steggoll [7] presented the case of a woman, twenty-five years old, with a destructive lesion of the head, neck, and intertrochanteric region of the femur. Biopsy had revealed that the lesion had not extended beyond the periosteum. The pathological diagnosis was chondrosarcoma. Local resection of the proximal sixteen centimeters of the femur was done, and the lesion was curetted from the excised segment. This was then autoclaved. The defect which had been produced in the excised segment by curetting the lesion was packed with autogenous bone chips, and the segment was reinserted. Union to the shaft took place in eleven months, but a pathological fracture through the transplanted segment occurred after one year. An autogenous bone graft from the tibia and iliac-bone chips were inserted. Progressive union and progressive hip fusion occurred. Nine and one-half months following the grafting procedure, the tibial graft fractured; but, in spite of this, bony union progressed with reconstitution of the graft. Full weight-bearing was allowed in two years. At follow-up examination four years and ten months after surgery, excellent bone structure and solid hip fusion in good position was demonstrated. Function was excellent.

In the discussion, Dr. J. Vernon Luck [8] said that the type of lesion is the key as to whether local resection or hemipelvectomy should be done. Secondary chondrosarcoma is much more amenable to local resection than is osteosarcoma, which is a highly malignant lesion carrying a poor prognosis. Even with a secondary chondrosarcoma, if the lesion has extended beyond the periosteum and has invaded soft tissues, one would not expect local excision to be successful. In determining the extent of surgery required, one must consider not only the pathological section of the biopsy specimen but also the roentgenographic and clinical findings. Once the diagnosis has been established, treatment should not be delayed as the growth pattern in this type of tumor suddenly may change.

The Use of Living Autogenous Costal Cartilage in Arthroplasty of the Hip Joint. A Preliminary Report. Dr. John J. Flanagan [9] had, through association with Dr. Lyndon A. Peer, a plastic surgeon, become interested in the potentialities of hyaline cartilage for use in orthopaedic surgery. The plastic surgeon, with the aid of autogenous hyaline cartilage obtained from the costochondral area of the anterior chest wall, can reconstruct the external ear. The cartilage is cut up into small pieces (diced) and is placed in a perforated Vitallium ear mold; this is buried in the anterior abdominal wall (extrafascially) for four months. A hyaline-cartilage mold of the external ear is thus obtained which furnishes the basic framework of the new ear.

Ingeniously applying the principles of this technique, Dr. Flanagan developed a hyaline-cartilage mold comparable in thickness and shape to the cartilaginous articular surface of the femoral head. The mold, upon removal from the abdominal wall, is a flexible implant consisting of living hyaline cartilage imbedded in connective tissue. The hip joint is opened and the femoral head is remodeled to fit the mold. The mold is applied carefully, is trimmed, and is secured to the femoral neck by chromic catgut purse-string sutures. The head is then restored to the acetabulum, and the hip and abdominal wounds are closed. The extremity is placed in balanced suspension for four weeks; this is followed by gradual weight-bearing. The author had performed this two-stage arthroplasty in three patients. The first, now nearly three years after operation, is a practical nurse, forty-three years old, who works regularly. She was reported to have excellent function and no pain.

[4] 1180 Beacon Street, Brookline 46, Massachusetts.
[5] 4952 Maryland Avenue, St. Louis 8, Missouri.
[6] 11460 Laurelcrest Road, North Hollywood, California.
[7] Pleasanton, California.
[8] 1930 Wilshire Boulevard, Los Angeles 5, California.
[9] 517 Centre Street, South Orange, New Jersey.

Dr. Flanagan requests that this very interesting piece of research be regarded as a preliminary experiment; he hopes that it will stimulate others to investigate the potentialities of hyaline-cartilage molds for use in orthopaedic surgery.

Generalized Hemangiomatosis of the Skeleton and the Spleen. Dr. Gorton Ritchie [10] and Dr. Francis G. Zeier [11] reported a case of generalized hemangiomatosis of the skeleton and spleen in a white boy, two years of age. Although his birth and development had been normal and his only complaint referable to the skeleton had been a pathological fracture of the clavicle six months prior to admission, roentgenograms revealed multiple, irregular, multilocular and monolocular, cystic lesions throughout the skeleton, with the exception of the epiphyses and the bones of the hands and feet. Laboratory studies, including serum calcium, phosphorus, and alkaline phosphatase estimations, were within normal limits. A biopsy of a cystic lesion of a rib revealed the marrow to have been replaced by widely dilated thin-walled spaces. Laparotomy revealed normal viscera, except for the spleen which was enormously enlarged with multiple cystic tumors. Aspiration of one of these cysts yielded yellow serous fluid containing erythrocytes. Histological examination revealed small areas of normal splenic tissue between tremendously distorted vascular spaces containing a few erythrocytes and a large amount of hyaline protein precipitate. At the time of the report, two and one-half years after laparotomy, the child had no complaint relative to the skeleton or viscera.

Symposium of Femoral-Head Endoprostheses

Dr. Claude N. Lambert [12] led off the panel discussion on femoral-head prostheses by reporting on the survey made by The American Academy of Orthopaedic Surgeons. He was Chairman of the Committee for the Study of Femoral Head Replacement Prostheses. The results have been published elsewhere and can be obtained from the Central Office of The Academy in Chicago. In general, there is a tendency toward using prostheses more often than was true a year ago, and a tendency toward the use of more intramedullary prostheses and fewer stem prostheses.

Dr. Philip D. Wilson, Jr.[13], reported for the Hospital for Special Surgery. Their experience has been almost entirely with the short-stem prosthesis of the Judet type. They feel, in general, that their results with the Judet prosthesis are superior to those from the Vitallium-cup arthroplasty; this impression is based on an evaluation of eighty-four patients one year or more after operation. Definite loosening of the prosthesis had occurred in eight of sixty patients with adequate roentgenographic follow-up; subluxation or dislocation had occurred in nine of the sixty. He reviewed the possible causes for loosening and instability. He emphasized that the stem prosthesis is of most value in their hands in the treatment of osteo-arthritis and femoral-neck fractures which had united. In ununited femoral-neck fractures, the short femoral neck required alteration of the usual technique and made for difficult placement of the prosthesis.

Dr. Carroll B. Larson [14] stated that, at the University of Iowa, they had operated on many patients with various hip conditions in whom they had inserted the femoral-head prosthesis. He emphasized that both the stem and intramedullary types of prostheses had loosened in their canal because of the erosive pressure of the prosthesis on the cancellous bone. He showed an example of absorption of the neck underneath the stem of a prosthesis and an example of an intrapelvic protrusion of a femoral-head prosthesis. These were shown in order that it might be made clear that metallic replacement substances in the region of the femoral head and neck are basically unphysiological and must be used with extreme caution and used only in attempts to salvage patients who otherwise would become wheel-chair or bed problems.

Dr. Mark B. Coventry [15] reported on the indications for the use of femoral-head prostheses at the Mayo Clinic. Because of the loosening of the stem prosthesis in several patients the use of this particular type has been abandoned. He stated that there were few, if any, indications for its use. The intramedullary prosthesis of Moore is now being used almost exclusively.

In general the four basic indications for use of the intramedullary prosthesis were:

1. Bilateral affections of the hip in which arthrodesis would be contra-indicated;
2. Unilateral affections of the hip in which there is a lack of viable bone in the head or neck of the femur;
3. Unless there is evidence of avascular or cystic changes in the femoral head which would prevent a cup from being used, osteo-arthritis and rheumatoid arthritis are preferably treated with a mold or cup;
4. In fresh fractures of the femoral neck in the very old or in patients with a poor prognosis.

Contra-indications listed were:

1. Youth;
2. Severe bone atrophy;
3. Previous infection.

Some other type of reconstruction procedure is indicated when these three contra-indications prevail;

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it has been Dr. Coventry's experience that the Colonna reconstruction can be used in many of these patients as a salvage operation.

Dr. Carl E. Badgley [16] showed movies of two patients, one with a cup arthroplasty and one with a femoral-head prosthesis, and emphasized that the results were equally good. However, he stressed that, in his opinion, the Smith-Petersen cup arthroplasty was a physiological operation because it allowed movement of the head in the cup and of the cup in the acetabulum and that the insertion of a femoral-head prosthesis was an unphysiological procedure because there is an attempt to blend bone with an inert metal. He admitted, however, that the cup actually did not move freely in most patients because of fibrosis and bony spurring about the cup. Dr. Badgley, as had all previous members of the panel, made a plea for conservatism, emphasizing that the ultimate fate of the femoral-head prosthesis is not known, and that three or four years' experience is not enough on which to base any definite opinions of prognosis.

Presidential Address. Dr. T. Campbell Thompson [17]. This address was published in the April issue of *The Journal of Bone and Joint Surgery*, pages 385 to 390.

Vitamin-D Resistant Rickets. Dr. Donovan J. McCune [18]. No abstract submitted.

Treatment of Ununited Fracture of the Carpal Scaphoid by Styloidectomy of the Radius. Dr. Lyman Smith [19] and Dr. Barry Friedman [20] presented a study of thirteen ununited fractures of the carpal navicular (scaphoid) which they had treated over a period of four years by excision of the styloid of the radius. Of these, they listed ten as having excellent results and three as having unsatisfactory results. Although the series was small and the follow-up was short, they were sufficiently impressed by the good results to recommend excision of the radial styloid as one of the methods of treating ununited fracture of the carpal navicular. They noted that, if styloidectomy did not give satisfactory results, arthrodesis of the wrist could still be done.

The Posterolateral Approach for Cancellous Bone-Grafting in Non-Union of the Tibia. Dr. Kenneth G. Jones [21] and Dr. Horace C. Barnett [22] presented a method of treatment of non-union of the shaft of the tibia in the presence of infection. Particular attention was directed to difficult cases in which the results had previously been disappointing, in spite of adequate treatment. The solution of the problem was based on securing union on the posterior surface of the tibia by synostosis of the tibia and the fibula above, at, and below the fracture area. Thus, the procedure conforms in principle to the basic idea of Phemister in regard to securing union without disturbing the interposing fibrous tissue between the fragment ends. The method consists in the application of cancellous-bone chips and strips in the area of non-union through a posterolateral approach. The fibula is exposed subperiosteally along its posterior and medial aspects through elevation of the flexor hallucis longus. The tibialis posterior is raised from the interosseous membrane and the flexor digitorum longus is raised from the posterior aspect of the tibia. It is in this interval that the grafts are applied. The method is one of indirect approach and it has merit. It is well to note that the posterior approach requires surgical skill and judgment; the steps in the procedure given in detail must be followed carefully and complications must be anticipated and prevented. Some of the complications listed are: hematoma, paraesthesia, excessive oedema, and possible infection through the contamination of the operative site by an opening through the interosseous membrane to the infected fracture area. Dr. Jones and Dr. Barnett had used homogenous and autogenous bone and a mixture of both of these. The ilium was the source of the autogenous bone grafts. No effort was made to determine which type of graft was preferable. No immobilization in the form of plates, rods, or other internal fixation was used. Two weeks after operation, when the wound had healed, a plaster cast was applied or support was rendered by a brace.

Dr. Robert Mazet, Jr.[23], doubted that fractures of the tibial shaft should be classed as having resulted in non-union in twenty to twenty-four weeks. Plaster fixation and prolonged patience resulted in union in a very high proportion of the cases reported by Dr. Urist to The Academy last year. It might be necessary to wait twelve months or more for union. He agreed that, when surgery is necessary, excision of the fibrocartilaginous callus and metallic fixation are unnecessary; he approved of the operation reported by Dr. Jones. He preferred, however, when indicated, to use the McMaster cross-bone-grafting between the fibula and the tibia.

Immunologic Factors in Homogenous-Bone Transplantation: Serological and Histological Studies. Dr.

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PAUL H. CURTISS, JR.[24], DR. CHARLES H. HERNDON [25], and DR. SAMUEL W. CHASE [26] presented a study which had been instituted to discover why autogenous bone grafts are more effective than heterogenous or homogenous bone grafts. The investigations and the results were described.

1. Iliac bone from dogs, the red blood cells of which contained the strongly antigenic "canine A factor", was transplanted into paravertebral muscle pockets in rabbits.

2. Whole knee joints were interchanged in five pairs of dogs, one dog in each pair being "A-negative" and the other being "A-positive".

3. Red blood cells of ten "A-positive" dogs were injected at weekly intervals into ten "A-negative" dogs. These twenty animals were treated as ten paired couples, and the injections were continued until an "anti-A" agglutinin titer of not less than one to 256 was obtained. At this point, an autogenous graft was placed in the distal portion of the right ulna and a "homogenous compatible" graft from a dog of the same blood type was placed in the proximal part of the same ulna. In the left ulna a "homogenous incompatible" graft from the partner of the opposite blood type was placed in the distal part of the bone. X-ray and histological studies of these grafts in the ulna were made.

4. Serological studies indicated that dog bone implanted into rabbits and other dogs acted as an antigen. However, no certain relationship between the ability of this bone to produce an antigen in the recipient animal and the red cells which this graft originally contained could be consistently demonstrated.

5. Histological studies showed that known blood-type incompatibility had no demonstrable histological effect on the healing of homogenous or autogenous iliac-bone grafts. Autogenous grafts showed consistently better response than did either type of homogenous graft.

Surgical Treatment of Sprain of the Tibial Tubercle. DR. J. E. M. THOMSON [27] reviewed his twenty years' experience in the treatment of Osgood-Schlatter disease, or as he prefers to term it "sprain of the tibial tubercle". The psychological problem, as well as the physical problem, was considered, and efforts to secure relief of pain and fusion of the tibial tubercle were reviewed. The operative methods, such as drilling of the area, the use of bone pegs, and the removal of fragments, with follow-up, were presented. The author noted that these various procedures, as a rule, relieved the pain in most of the patients and eventually fusion resulted. However, the unsightly prominence of the tibial tubercle remained. Thus, in order to relieve the pain and to improve the appearance cosmetically, a more extensive operative procedure was devised.

The procedure consists in splitting the patellar tendon longitudinally over the tubercle; the tendon is elevated and retracted subperiosteally on each side of the tibial tubercle. The cortical and cancellous bone, as well as the cartilaginous fragmentation, are excised; in fact, the entire area of deformity is removed. The terminal and lateral attachments of the tendon are left intact, and the upper tibial epiphysis is not disturbed. The tendon drops back over the depressed and denuded area; closure of the wound is accomplished; and a compression dressing and a cylinder (walking cast) is worn for two weeks.

The procedure performed on eighteen knees has been satisfactory in Dr. Thomson's hands in every instance; it is offered by him for the relief of the symptoms, as well as for the improved appearance. It is not suggested for use in patients who will respond to conservative treatment.

Roentgenograms and operative diagrams were shown, demonstrating the beneficial effects of the procedure. No photographs of the areas before and after operation were presented.

In discussion, DR. ANTHONY F. DEPALMA [28] stated that it had been his experience that youngsters afflicted with osteochondrosis of the tibial tubercle rarely complain because of a prominence on the front of their knee joint. They do object, however, to the restriction of activities which is often forced upon them because of the existing lesion. He did not recall any patient to whom this lesion had been a deterrent to normal emotional development. He had, on rare occasions, encountered patients in whom severe symptoms had failed to respond to the orthodox methods of treatment. He had also seen a few in whom the prolonged disability which had been produced in otherwise healthy, active adolescents did justify some form of surgical intervention in order to halt the pathological process. He had found that drilling of the tubercle did result in the termination of symptoms and in rapid healing. However, the residual prominence was invariably larger than the one before the operation. For this reason he had discarded the method. It was emphasized that, in the early stages of this disorder, no roentgenographic evidence of bone involvement may be discernible. However, there is definite clinical and roentgenographic evidence of thickening of the patellar tendon. Ferguson (*Roentgen Diagnosis of the Extremities and Spine*, 1949) pointed out that the primary lesion is in the tendon near its point of insertion into the tubercle, that the disorder is caused by stress, is developed by rapid growth, and is expanded on the patellar tendon near its bony insertion. The resulting hemorrhage, swelling, and degenerative changes in the tendon are primary; the irregular ossification within the underlying bone is secondary. He proposed making longitudinal cuts in the tendon for decompression and relief of the

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circulatory embarrassment of the underlying bone. He had performed this procedure many times. It relieves the patient of pain and induces healing of the tubercle. However, while it does not minimize the protuberance, it does not increase it. In addition he removes the deforming osseous elements.

Non-Specific Tenosynovitis and Its Treatment. Dr. Emil D. W. Hauser [29] described a non-specific tenosynovitis which is manifested by swelling of one or more of the tendon sheaths in the region of the ankle. This he believed to be due in part to foot strain. The condition is most commonly seen in the sheath of the peroneal tendon and the sheath of the tibialis anterior tendon, with swelling posterior to the lateral malleolus or anterior to the ankle joint. He had also seen the condition in the tendon sheath of the common extensors of the toe and in the tendon sheaths of the tibialis posterior and the extensor hallucis longus. In addition, some patients had synovitis and effusion of the ankle joint. In one patient, the tendon and the tendon sheath had been explored, and the condition had been demonstrated at surgery.

The process is non-infectious in origin and apparently is not rheumatoid. Conservative treatment by the injection of hydrocortone into the involved tendon sheath and correction of the position of the foot gives more satisfactory results than does surgery. This relatively rare condition should be differentiated from such conditions as traumatic stenosing tenosynovitis, infectious tenosynovitis, and tuberculosis.

The Effect of Anticoagulant Therapy on Bone Repair. Dr. Frank E. Stinchfield [30], Dr. Balu Sankaran [31], and Dr. Robert Samilson [32] reported the results of their study of the effect of heparin and dicumarol on bone repair in rabbits and dogs. In an experimental group of sixteen rabbits and nine dogs and a comparable control group, bone grafts were made by removing a semicircular disc of bone from the iliac crest and replacing it immediately. These were secured by two tantalum wires. In the experimental animals, heparin was administered in a dosage sufficient to maintain the clotting time at twenty-five and thirty minutes, while the dicumarol dosage was adjusted to give a prothrombin time by the Quick two-stage method of thirty to thirty-five seconds. The following dosage schedules were followed: (1) Either heparin or dicumarol was given preoperatively; (2) either heparin or dicumarol was administered twenty-four hours postoperatively and was continued for three weeks in rabbits and for four weeks in dogs; (3) either drug was given one week postoperatively and was continued for two weeks in rabbits and for three weeks in dogs; (4) a combination of the two drugs was given either twenty-four hours postoperatively and was continued for three weeks in rabbits and for four weeks in dogs or was given one week postoperatively and was continued for two weeks in rabbits and for three weeks in dogs. The rabbits, both experimental and control, were sacrificed three weeks postoperatively, while the dogs were killed at four weeks after operation. All animals were healthy; their wounds had healed without infection; and autopsy revealed no gross hemorrhages. All of the control animals had early bony union. The animals in which anticoagulants had been administered showed delayed union. Those which had received anticoagulants immediately postoperatively showed fibrous union, while all of those which had received anticoagulants at one week postoperatively showed delayed union.

The possible mechanisms which might be responsible for these results were discussed. It was suggested that, because of the use of anticoagulants, there were: (1) lack of fibrin clot, (2) a diminution of prothrombin concentration due to dicumarol with resultant inadequate local calcium concentration for bony union, and (3) a substrate competition mechanism involving the two mucopolysaccharides, chondroitin sulphuric acid and heparin. In support of the latter mechanism, sections which had been stained with toluidine blue showed a diminished mucopolysaccharide content in the experimental animals in which heparin and dicumarol had been administered immediately postoperatively. Furthermore, a diminution in the number of cells at the graft site was noted in the experimental animals; this suggested a toxic effect of these drugs. It was specifically stated that non-union would not necessarily result from anticoagulant therapy in human patients, but it was suggested that the possibility should be considered. The possible significance of these findings in the general field of fibrous-tissue behavior was suggested.

Dr. Charles H. Herndon [33] remarked that the evidence is clear that dicumarol and heparin, alone or in combination, seriously affect bone healing in rabbits and dogs. He feels that the definite retardation of bone healing, noted when the anticoagulant therapy is not started until one week postoperatively, indicates that the effect is totally unrelated to the blood-clotting mechanism. He feels that the action of dicumarol might be to block a vitamin K effect by means of which there is interference with the availability of the phosphate ions necessary for bone formation. These, however, are purely speculative ideas and further investigations along these lines will prove quite helpful in elucidating certain metabolic factors involved in bone formation. Clinically one should be cautious with regard to the administration of heparin or dicumarol to patients in whom bone healing is expected.

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Prognosis in Dislocations of the Shoulder. Dr. Carter R. Rowe [33] presented a detailed statistical study of dislocations of the shoulder in all age groups and from all causes with the intent to determine if any facts are available which would help to prognosticate the outcome of a dislocation in any single case. The records of 500 dislocations of the shoulder were available at the Massachusetts General Hospital; 313 of these contained adequate details for this particular study.

Recurrent dislocation is apt to follow initial traumatic dislocation in 38 per cent. of all patients with traumatic dislocation regardless of the complications or of the treatment of the original dislocation. The age of the patient at the time of the original dislocation is the most significant single prognostic factor. This is attested by the fact that the incidence of initial dislocation was highest in the older age groups, yet the incidence of recurrence was highest in the younger age groups,—namely, under thirty. The greater the initial trauma was, the lower the recurrence rate; the more difficult the reduction was, the lower the recurrence rate. Initial dislocations which had been immobilized for three weeks showed the lowest recurrence rate. Handedness had no statistical bearing on the prognosis. Dislocations occurring in epileptics showed a 91 per cent. recurrence rate (nine of ten patients; eleven shoulders) and rather severe humeral-head defects were found in eight shoulders. Associated nerve injuries in all traumatic dislocations occurred in 5.4 per cent.; these included, in order of incidence, injuries of the ulnar nerve, the radial nerve, the axillary nerve, and the median nerve, with the greatest incidence of injury being a combination of one or more of these. Of the patients with nerve injury, 15 per cent. had permanent damage.

Dr. Chalmers R. Carr [34], in discussion, pointed out that the mechanism of dislocation of the shoulder was a very slight twist in 84 per cent. of the initial dislocations; this corresponds with findings of other observers, such as Dr. J. C. Adams. He questioned whether complete motion in the shoulder is one of the criteria necessary to rate a result *excellent*. In answer to this, he quoted Mr. Osmond-Clarke as saying, "successful treatment depends upon limitation of external rotation". Dr. Carr further pointed out that, in the evaluation of surgical repairs in recurrent dislocation of the shoulder, there was little difference in the success of the Bankart operation as compared with that from the Putti-Platt operation. He felt this to be of some significance since the Putti-Platt operation was much more easily accomplished.

Dr. John C. Wilson, Jr.[35], urged three weeks of immobilization with the arm in a sling or bandaged to the side. Supervised gradual exercises should then be done. The resumption of free use of the joint before three weeks is hardly consistent with sound healing of the torn capsule. He called attention to the difficulty of diagnosing posterior dislocations unless lateral or stereoscopic roentgenograms are made. He had found that long unrecognized posterior dislocations require open reduction. To maintain reduction he had found it necessary to employ temporary wire fixation; the greater tuberosity of the humerus and the spine of the scapula being held together by a transfixion wire for three weeks. For the treatment of recurrent anterior dislocation, he preferred to use the Bankart operation.

Recurrent Dislocation of the Shoulder. Twenty-four Year Study of the Johannesburg Stapling Operation. G. T. duToit, F.R.C.S.[36], and D. Roux [37] reported on 210 cases of recurrent dislocation of the shoulder operated upon by the so-called Johannesburg stapling operation. All of the pertinent facts and findings including follow-up in 150 cases since 1931 had been accumulated. Following the first operation by F. P. Fouché, the technique had been improved and simplified. They pointed out an easy and quick method of achieving fixation of the capsule at the anterior labrum of the glenoid. Only one patient in the series did not have the typical lesion,—namely, an easily recognizable Bankart lesion. Other findings were of interest: 11 per cent. showed a bucket-handled labrum, 21 per cent. had a well marked bare area on the scapular neck medial to the glenoid margin, and 10 per cent. had bony damage to the glenoid margin. In 33 per cent., a notch on the posterolateral aspect of the head of the humerus was demonstrated roentgenographically and by operation. Of the patients, 92 per cent. were males and 95 per cent. were under forty years of age. An evaluation of the results showed that operation did not restrict external rotation. Many of the patients most recently operated upon were away from work not more than two weeks. In the final evaluation, there had been recurrence of the dislocation in 5 per cent. This figure is misleading, since, in all but three instances, the recurrence could be ascribed to an early error in technique or to sepsis. The staples first used had been made from bicycle-spoke material; these caused such technical complications as erosion and migration. The only other complication reported, aside from the ordinary incidence of infection, was damage to the musculocutaneous nerve from hemostatic suture. The nerve recovered.

It was emphasized that when the Bankart lesion is found, the specific cure is achieved by repairing the anatomical lesion only. There is no need to perform such additional procedures as overlapping, plication, or suspension. Permanent disability is minimal, complications are rare, and the remote prognosis is satisfactory.

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Release of the Rectus Femoris in Spastic Paralysis. Dr. William R. Duncan [38] presented a surgical procedure for use in the treatment of spastic paralysis which has an interesting physiological background. He feels that the improvement which follows release of the rectus femoris at its origin is due not only to the elimination of the check-rein effect of this two-joint muscle but also to the increase in the useful range of motion between stretch reflexes. This latter consideration seems to be in keeping with Sherrington's law of reciprocal innervation in that, if a spastic muscle is subjected to stretch, its antagonist is reflexly inhibited. In addition, it was noted that the pelvis was allowed to rotate backward into a more normal position; this, in turn, allowed the origin of the hamstrings to settle to a lower level. The flexor effect of the hamstrings was thus decreased.

He presented in detail two tests for contracture of the rectus femoris.

Follow-up studies were presented for twenty-one patients in a series of thirty-two. Postoperative gains included release of flexion contracture of the hip, relaxation of the hamstrings, gain in height of the patient, and an increased range of motion between stretch reflexes at the knee.

Dr. H. Relton McCarroll [39], in the discussion, pointed out that, in his opinion, the release of the rectus femoris at the pelvis had a beneficial effect on flexion of the hip joint. He called attention to what he believes is a fact that there was no improvement in flexion of the knee as shown in the moving pictures of the patients presented.

A Rational Approach to the Surgical Needs of the Cerebral Palsy Patient. Dr. Lenox Baker [40] summarized his experience in the surgical correction of deformity in patients with cerebral palsy. In a total of 186 patients, 590 surgical procedures had been carried out; 164 of the patients operated upon had been selected from 977 consecutive cases in the North Carolina Cerebral Palsy Hospital, an incidence of 16.7 per cent.

It was recommended that early surgery be carried out to correct deformity and to decrease hypertonicity in order to facilitate the physical therapy which is an essential part of the treatment of the patient with cerebral palsy. Many of the procedures which have been used in the surgical treatment of poliomyelitis are applicable to the problem of the patient with cerebral palsy. The benefit to be derived from these procedures, however, must be evaluated in terms of the individual patient. Careful evaluation must be made before surgery. The patient should have a sense of balance if it is hoped to have him walk following the surgical correction. Dr. Baker emphasized that only a small proportion of patients with cerebral palsy are candidates for surgery. This limited group is made up of those who have spasticity rather than those who have athetosis and ataxia. It is essential that the mentality of the patient be evaluated before any form of treatment is attempted, surgical or otherwise.

The primary goal of surgery is the correction of muscle balance, the alignment of weight-bearing joints, the restoration of the control of the joints, and the correction of posture. The surgical procedures performed to obtain these goals were primarily those which are carried out to decrease spasticity, to restore proper length to the muscle, to correct joint alignment, and to decrease or to control the overflow to or from the muscle. The common deformities about the hip, the knee, and the foot were described, together with the procedures which he had found helpful in the correction of these deformities. The deformities are frequently seen in combination, and it is difficult to determine which deformity is primary in nature and which might be compensatory. A careful evaluation should be made to determine which deformity is most likely to be the primary element; this should be corrected first.

The most common deformity of the foot encountered was an equinovalgus deformity. The procedure most commonly used for the correction of this deformity was the lengthening of the aponeurosis of the gastrocnemius; if there had been spasticity of the peronaeus longus and peronaeus brevis, one of the tendons was transplanted to the tibialis posterior. If these procedures had been carried out early, before bone and joint changes had occurred, a well balanced foot often resulted. If the procedure had been postponed too long, an extra-articular subtalar arthrodesis was performed. In some instances, the pes planus had been corrected by the procedure described by Miller. In all instances, when arthrodesis had been performed, a lengthening of the triceps surae had also been carried out.

Flexion deformity of the knee was corrected by a lengthening of the hamstring tendons. This procedure was frequently combined with recession of the heads of the gastrocnemii. For correction of the adduction deformity, tenotomy of the adductor longus and gracilis was performed in combination with partial neurectomy of the obturator nerve. For correction of hip-flexion deformity and internal-rotation deformity, a division of the iliotibial band, after the method described by Yount, is recommended. Transplantation of the tensor fasciae latae posteriorly to the wing of the ilium was recommended in order to correct internal rotation of the hip and also to improve abduction. Occasionally, lengthening of the rectus femoris and iliopsoas muscles may be necessary in order to obtain full extension of the hip. The author described variations in techniques which have proved helpful in his experience.

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Internal Fixation in Displaced Intracapsular Fractures. Dr. George O. Eaton [41] reviewed his experiences with nail-plate internal fixation for displaced fractures of the neck of the femur. In 1948, Dr. Edward J. Haboush presented an exhibit at the meeting of The American Academy of Orthopaedic Surgeons in which, by photo-elastic stress and strain analysis, it was shown that the nail-plate, inserted low in the neck of the femur so that it rests on the calcar femorale distal to the point of the fracture, is the ideal appliance for fixation of this type of fracture. In 1951, the author began to use this form of fixation, and in eighteen patients who were followed for more than one year clinical union had occurred in every instance. He cited the two main objections to the use of the nail-plate: First, additional exposure was required and the length of time of the operation was prolonged (this was not judged to be significant if more secure fixation could be obtained). Second, there was the danger of protrusion of the nail through the head of the femur and into the acetabulum during the postoperative period. This, however, did not occur to an objectionable degree in Dr. Eaton's series of thirty-six cases; indeed, the added immobilization was believed to have decreased the degree of absorption of the femoral neck. It was concluded that this method of fixation is safe and, because of the more efficient immobilization afforded, is more apt to result in solid union of the fracture.

Dr. A. J. Neufeld [42], in discussing this paper, pointed out the importance of adequate reduction of the fracture and adequate internal fixation in obtaining a high incidence of union of fractures of the femoral neck.

The Immobilizing Efficiency of Back Braces. Dr. Paul L. Norton [43] and Dr. Thornton Brown [44] discussed the pertinent question of the efficiency of the various supportive apparatuses utilized for the treatment of low-back disabilities. On models with clinically normal spines, the Goldthwait, Taylor, Arnold-Abbott, Jewett, chair-back, and Williams braces were tested by means of (1) photographs of the models in various positions, (2) lateral x-rays of spinal motion taken under fixed conditions—with and without the use of a brace, (3) observation of the changes in the angles of Kirschner wires placed in the spinous processes of appropriate vertebrae and the posterior superior spine of the ilium, and (4) the use of pressure strain gauges attached to the brace. While these methods are admittedly not exact, the study left definite impressions as to the immobilizing action of the braces in various positions. It was pointed out that there is a wide variation in lumbosacral flexibility in the normal spine in forward bending and that there is a marked degree of lumbosacral motion in the normal erect sitting position. The effect of these on the use of braces was discussed. They found that the paraspinal vertical uprights used on most back braces distribute pressure on a wide and changing area in different positions of spine flexion; this resulted in a loss of the effectiveness of the brace. For instance, fixation of the lower lever arm of the brace (the pelvic band) depends on the tautness of the lowest straps which are attached to the abdominal pad, and it does not occur until these straps have tightened against the thighs—this does not take place early in flexion in the braces now in common use. With long braces which are well fixed to the chest, pressure of the brace migrates upward during flexion to limit thoracolumbar motion but not lumbosacral motion. Short braces which are well fixed to the pelvis, but poorly fixed to the chest, tend to keep the maximum point of pressure at lower levels. The writers feel that a brace designed to limit lumbosacral motion must deliver pressure which is sharply localized, rapidly built up with the first few degrees of forward bend, and positively uncomfortable as the acceptable limits of spinal motion are exceeded.

A brace which they feel meets these qualifications was presented.

Late Effects (Twenty-five to Forty Years) of the Early Medical and Industrial Use of Radio-Active Materials. Their Relation to the More Accurate Establishment of Maximum Permissible Amounts of Radio-Active Elements in the Body. Lt. W. B. Looney [45] reported on the follow-up studies of fifty patients who had received radium salts therapeutically, twenty-eight individuals who were employed as luminous-dial workers, and twenty-one patients who had received thorotrast in diagnostic roentgenographic procedures. The study covered the years from 1915 to 1940. An attempt was made to correlate autoradiograms (both gross and detailed), photomicrographs, and roentgenograms of the patients' bones. Whenever possible routine postmortem histological sections were studied, as well as physical and symptomatic findings.

In the case of radium, the following facts were reported: When radium has been taken into the body, about 90 per cent. of it is eliminated. The radium which is retained is deposited irregularly in the skeleton in small areas of high radium concentration. Roentgenographic changes, characteristic of the deposition of radium, are seen to develop years after the administration of radium. Areas of decreased density occur in compact bone as a result of bone destruction, and areas of increased density occur in cancellous bone as a result of atypical bone formation. There may be increased fragility of the skeleton after radium deposition; therefore, fractures and aseptic necrosis will occur with increased frequency. With the deposition of radium, minor hematological changes may develop. Aplastic anaemia is infrequent. However, the sedimentation

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rate is usually elevated. With this exception, laboratory examinations are non-contributory. Malignant disease of the skeleton may develop after the deposition of radio-active elements. The areas of decreased density seen on roentgenographic examination of the skeleton may be the first clinical evidence of malignant disease.

Concerning thorium, it was emphasized that almost all of the thorium from thorotrast is indefinitely retained after administration. Primarily, it is deposited in the liver, the spleen, and the bone marrow; there may be lesser concentrations in the lungs and adrenal glands. In general, there is comparatively little reaction and destruction. An exception to this, however, is found in the spleen. At the sites of injection, there was extravasation of the thorotrast in the soft tissue. The presence of thorotrast was demonstrated roentgenographically in the liver and the spleen, as well as at the sites of extravasation in the neck and arms. Slight thickenings of the shafts of the long bones and trabecular markings, as well as irregularity of the endosteum, were demonstrated roentgenographically. Work is at present in progress to determine if there is any relation between the roentgenographic changes and the administration of thorotrast. Symptoms may arise from the marked contraction and induration at the sites of injection. In patients who had had thorotrast administered, there were minor hematological changes; anaemia has been reported. The results of liver-function tests were abnormal in some patients. However, it was pointed out that interpretation was difficult because of the underlying condition for the diagnosis of which thorotrast had been given. No conclusion concerning the possible relation between the administration of thorotrast and the development of malignant disease of the liver and leukaemia was reported.

Dr. Justin J. Stein [46] stated that efforts can be made to guard against or to minimize the effects of external radiation, but internal radiation must be prevented if at all possible. The long half-life of bone-seeking radio-active elements carries with it grave hazards, for a minute amount of a radio-active element fixed in the skeleton can be very harmful, as shown by studies of the luminous-dial workers, of those who had drunk radium water for the treatment of arthritis, or of those who had received radium injections in the treatment of Hodgkin's disease, arthritis, or other conditions. While people may be severly disabled by the injection of radio-active elements, death does not usually result directly from the effects of the isotopes unless malignant disease develops. Some people live for many years in reasonably good health despite fixed amounts of radium. It cannot be predicted which individuals will be adversely affected by radio-active elements.

Stimulation of Bone Growth. Dr. S. L. Haas [47] reviewed the literature for eighty-five years from von Langenbeck to Strobino relating to the experimental stimulation of bone growth. He described his own numerous experiments in this field; these included a wide variety of techniques. The mechanical devices employed in these experiments had been designed to stimulate, to restrict, or to measure the rate of bone growth at a given epiphyseal plate. Wire loops of different metals encircled epiphyses and other wire loops encircled the medial and lateral condyles of the lower portion of the femur. In all of these experiments bone growth was retarded.

Metal implants were inserted into the metaphyses and the epiphyses. Iron, copper, aluminum, and black-manganese oxide were employed; these metals were implanted directly into either epiphyses or metaphyses, or both. These experiments failed either to stimulate or to retard bone growth.

Growth hormones were employed and were placed in small cavities created in the epiphyses, the metaphyses, or in the soft tissues overlying the metaphyses. Pituitary hormone was used principally. No stimulation of length resulted. In one of the experiments, the femoral vein was ligated, and the pituitary hormone was injected into the femoral artery and around the epiphyseal plate. In this experiment also, there was no stimulation of bone growth.

Traction experiments were done in which wire loops had been placed around the femur at the level of the lower femoral epiphysis and around the tibia at the upper tibial metaphysis. Between these wire loops expansion devices which consisted of a coil spring inside a metal tube had been implanted in the tissues. An expansion force was thereby created. Neither acceleration nor retardation of bone growth resulted.

Although none of these experiments had been successful, they were reported in the hope of stimulating other investigators to carry out similar studies.

The Effect of Compression on the Growth of Epiphyseal Bone. Dr. L. J. Strobino [48], Dr. Paul C. Colonna [49], Dr. R. S. Brodey [50], and Dr. Thomas C. Leinbach [51] reported on an investigation, in progress for more than five years, made in order to determine the force of growth of bone at the epiphyseal cartilaginous plate, the effect on the rate of growth of increasing compression, and the capacity to resume growth following prolonged arrest. Twelve Holstein calves had been used. The study had, in part, been previously

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reported, and the description of the devices used in measuring the forces generated and many of the determinations had been given (*Surgery, Gynecology and Obstetrics*, **95**: 694–700, 1952). From these studies the following observations were reported. Graphically, the growth rate remained unchanged almost up to the level of arrest; for the young calves it was almost a straight line. The force necessary for the arrest of growth in the upper tibial epiphyseal plate was approximately equal to the animal's weight. This amounted to about forty-five pounds per square inch. Growth occurred at practically a normal rate until it had been stopped. In one animal, bone growth had been arrested for seven months; there was marked shortening and a decrease in the diameter of the bone. When the epiphyseal cartilaginous plate had been released from arrest, there was evidence that growth was immediately resumed and was greatly accelerated. Eventually the limb became practically equal in length and diameter to that of the opposite side—an increment of 2.8 centimeters.

The Correction of Discrepancies in Growth of the Lower Extremities. Dr. William T. Green [52] and Miss Margaret Anderson [53] reported a series of 475 operations performed for equalization of limb length by inhibiting growth in the longer extremity. Of these, 383 were epiphyseodeses and ninety-two were staplings. For the purposes of this study, only 237 patients in whom epiphyseodesis had been done and fifty-two patients in whom epiphyseal stapling had been done were selected. In the 237 patients in whom epiphyseodesis had been done, growth was completed, and complete records and measurements were available for study. Of the fifty-two patients with stapling, only thirty-three had been followed until closure of all epiphyses; the other nineteen had been followed for at least two years.

The accuracy of prediction charts was evaluated, and it was found that, in 89.6 per cent. of the patients, correction was obtained within 1.3 centimeters of the predicted amount. The most common causes of error were the failure of the distal tibial epiphysis of the short limb to contribute an adequate amount of growth, failure to assess the patient's skeletal maturation correctly, failure of the arrest to take effect rapidly, and the relative size of the patient,—that is, a short person would not be as much affected by an arrest as would a tall person.

The incidence of secondary operations in the 237 patients in whom epiphyseodesis had been done was 8 per cent. There were five osteotomies for the correction of deformity, five arrests of the femur of the short limb in order to prevent overcorrection from the arrest, and five instances of secondary operation when the first arrest had not been effective. It was pointed out that all of these patients had good to excellent clinical results in the final analysis. Had these patients not had careful postoperative supervision and secondary procedures, the results might well have been classed as complications (8 per cent.). The need for supervision of patients who have had epiphyseal arrests was well demonstrated.

After comparing the accuracy of the predictions based on the skeletal ages obtained from the Todd Atlas and from that of Greulich-Pyle, they concluded that either is a satisfactory working guide, with certain modifications.

In the series of fifty-two staplings, there was a high incidence of secondary procedures, but these usually were of minor importance. The staples broke or were displaced; in some instances, they caused asymmetrical fusion. More difficulty had been encountered in stapling the tibia than the femur. Stapling proved to be an effective method of inhibiting growth. Whether growth will proceed in a normal fashion after removal of the staples could not be answered from the experiences in this series. In most instances, the staples had been inserted as a definitive procedure. In three instances in which the staples had been removed after two years, growth occurred in an amount equal to that in the opposite side.

Spondylolisthesis. A Critical Review of a Consecutive Series of Cases Treated by Arthrodesis. Dr. David M. Bosworth [54], Dr. J. W. Fielding [55], Dr. Lawrence Demarest [56], and Dr. Mario Bonaquist [57] reported a series of 115 patients with spondylolisthesis treated by spine fusion, with an average follow-up of four years in seventy-five cases. The location of the lesions was at both the fourth and fifth lumbar interspaces in one case, at the third lumbar vertebra in two, at the fourth lumbar vertebra in nine, and at the fifth lumbar vertebra in 102. The average slip was 2.5 per cent. at the third lumbar vertebra, 10.5 per cent. at the fourth lumbar vetebra, and 20.8 per cent. at the fifth lumbar vertebra, an average slipping of 19.3 per cent. for the group as a whole. The amount of the slipping did not appear to be related to either age or duration of symptoms. Slipping seemed to progress to about 20 per cent. and then be checked by some mechanism. In only two patients, however, were roentgenograms available showing progressive slipping preoperatively.

Prominence of the spinous process of the fifth lumbar vertebra in spondylolisthesis at the fifth lumbar interspace was found to be caused by (1) backward extrusion of the arch of the fifth lumbar vertebra in 17.5 per cent. and (2) cephalad rotation of the arch of the fifth lumbar vertebra until the spinous process impinged

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against that of the fourth lumbar vertebra in 82.5 per cent. This latter mechanism tended to check slipping at about 20 per cent. When slipping exceeded 20 per cent., the fourth lumbar vertebra was generally found to have slipped forward over the lamina of the fifth lumbar vertebra. In this connection, it was found that in nineteen of sixty-four patients in whom the arch of the fifth lumbar vertebra had been removed at the time of fusion some progression of slipping occurred postoperatively, while in eleven patients in whom the arch had been left *in situ* no such progression was found.

Findings associated with the spondylolisthesis included:

1. Bony bridges across the defects bilaterally in six patients and unilaterally in one patient;

2. Spina bifida of the fifth lumbar vertebra in nine patients and of the sacrum in twenty-one patients;

3. A typical herniated disc at the fourth lumbar vertebra in only one of the sixty-one patients in whom the arch had been removed;

4. Narrowing of the interspace above the lesion in seven patients and below the lesion in fifty patients;

5. Sclerosis of the abutting vertebral margins in all patients with narrowing of the interspace but with no true osseous proliferation of the sacrum anteriorly except for osteo-arthritic hypertrophic changes;

6. Alterations in the anterior vertical and anteroposterior horizontal diameters of the displaced segment in some patients, which seemed unrelated to the amount of slipping;

7. Wedging or diminution of the posterior vertical diameter in fifty-four patients which was considered to be directly related to the amount of slipping;

8. Underdevelopment of the arch which showed no correlation with the amount of slipping in forty-five patients;

9. Restriction of motion at the interspace below the displaced segment in forty-two patients and in the interspace above in seven patients, as shown by roentgenograms made with the patients in flexion and extension;

10. An increased lordosis of the lumbar spine, exclusive of the lumbosacral segment, which appeared to be related to the posterior wedging of the displaced segment and degeneration of the disc but not to the amount of slipping or to the severity of symptoms in less than a half of the patients;

11. Lumbar scoliosis in twenty-six patients which seemed to be related to the instability of the displaced segment but not to the amount of slipping.

The history given by these patients suggested disc herniation but the clinical findings failed to substantiate this. Clinical findings included limitation of motion (forty-nine patients), palpable notch (forty-six patients), tenderness (forty-five patients), positive Lasègue's sign (thirty-nine patients), protection (twenty-six patients), spasm (twenty-four patients), lordosis (twenty-four patients), hypotonicity of buttocks and thigh (twenty-three patients), trunk shift (twenty-two patients), atrophy (fifteen patients), hyporeflexia at the ankle (fourteen patients) and at the knee (eleven patients), sensory changes (eleven patients), and dorsiflexion weakness of the foot or the great toe (four patients). None of these findings were demonstrable in thirteen patients. The authors did not consider these findings to resemble typical extradural nerve-root pressure.

The results of seventy-five fusion operations were reviewed. Of these, sixty-six fusions extended from the fourth lumbar vertebra to the sacrum, six from the third lumbar vertebra to the sacrum, two from the third lumbar vertebra to the fifth lumbar vertebra, and one from the second lumbar vertebra to the fourth lumbar vertebra. The arch was removed in all but eleven patients. Otherwise the technique was uniform in all patients. It consisted in the application of an autogenous, cortical distraction or clothespin graft taken from the ilium; this was supplemented by iliac cancellous strips implanted beneath it. The average hospital stay was 24.6 days. A lumbosacral belt or brace was worn for four months to two years after surgery, the average being 8.9 months. The operative findings at the pars interarticularis were thin or heavy fibrous bands and a pseudarthrosis or bony continuity. Ossified plaques in the fibrous bands in some patients suggested attempted ossification in the defect. Nerve-root pressure exerted by the fibrous tissue in the defect, as described by Gill, was not observed. Of the seventy-five patients operated upon, two died of unrelated causes before the solidity of fusion had been established, sixty-two (84.9 per cent.) had solid fusion, and eleven (15.1 per cent.) had pseudarthrosis at some level. Five pseudarthroses were repaired and solid fusion resulted in four. Thus 90.4 per cent. of the operations resulted in solid fusion. Of the seventy-three patients in whom end results were evaluated, sixty-five (89.0 per cent.) were asymptomatic, and five of the seven patients with pseudarthrosis had continuous pain, two of them being disabled. Four patients with solid fusion had symptoms, but all of these were at work. The authors concluded that the pain in spondylolisthesis is due to the impingement of bone elements and abnormal stress on fibrous and ligamentous tissue and that, once solid fusion has been obtained, mechanical support of the displaced area is permanent.

Dr. William H. Bickel [58], in discussing this paper, suggested that the removal of the loose arch did not seem to be warranted unless there was evidence of nerve-root pressure.

Dr. Robert I. Harris [59] stressed the importance of motion as a cause of both back pain and sciatic

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pain in spondylolisthesis. In his experience with over 200 cases of spondylolisthesis, successful fusion gave complete relief of symptoms. He presented two cases illustrating progressive forward slipping of the involved vertebra. He stressed that spine fusions for spondylolisthesis of the fifth lumbar vertebra should not extend above the fourth lumbar vertebra, that the arch should not be removed, that a solid graft should be fixed above and below so as to extend along the whole length of the fusion area, that cancellous bone should be used in addition, and, finally, that recumbency for a minimum of four months should be maintained to allow the graft to become strong enough to resist average stresses.

The Role of Isotopes in Orthopaedics. Dr. Stafford L. Warren [60] said that during the late 1920's, orthopaedists, roentgenologists, pathologists, and physiologists combined to investigate the weight-bearing and working pressure exerted on joints and tendons and to study the restoration of function of muscles and tendons. In addition, electrical phenomena related to muscle function began to be applied to clinical problems, and studies were undertaken on the relation of nutrition and hormones to bone and muscle. In 1930, radio-active phosphorus (P^{32}) and radio-active sodium (Na^{24}) became available; and, subsequently, other isotopes, such as radio-active sulphur (S^{35}), radio-active carbon (C^{14}), and radio-active calcium (Ca^{45}) were also made available. New fields of research with refined methods for the identification and the measurement, particularly of "rates" in living systems, were opened. Instruments and techniques were developed, including counters and autoradiograms for recording ionization and, more recently, spectrophotometric methods based on differences in mass of the isotopes. Coincidentally with the development of these instruments, new uses for isotopes were found, including the synthesis of isotopes into more complex molecules. Already considerable information has been gained by use of these methods, as well as a clearer understanding of the metabolic pathways and the rates of the metabolism of inorganic salts, in particular those of P^{32}. However, there is still a wide field for their application, such as investigation of the crystalline structure of bone, the role of the osteoclast, and the processes regulating bone metabolism.

In closing, Dr. Warren re-emphasized the importance of the team approach to experimental problems because of the involved nature of the problems now confronting the investigator and the complexity of the techniques necessary to solve the problems.

Posterior Arthrodesis of the Ankle Joint. Dr. O. Sherwin Staples [61] described his technique of posterior ankle fusion, which is a modification of Campbell's method. Through a posterior incision dividing the tendo achillis, the posterior portions of the tibiotalar and subtalar joints are denuded of cartilage and are packed with cancellous iliac bone. A cortical graft from the posterior portion of the ilium is inserted into a bed prepared for it on the posterior aspect of the tibia and the talus, which extends down into a well-like hole in the superior aspect of the calcaneus. The graft is fastened to the tibia with a single screw. Postoperatively, the leg is immobilized in a long cast with the foot in 5 to 10 degrees of plantar flexion and with the knee in 30 degrees of flexion for two to three months. Afterward, a short cast is worn until healing is solid. The procedure is not recommended when preservation of the subtalar joint is desirable. The advantages cited were that the approach is simple, that a long bed for the graft can be obtained in the distal segment, and that the subtalar joint is readily included when this is indicated.

The successful use of this method was illustrated by case reports including those of a patient with bilateral, compound, severely comminuted ankle fracture, two male patients with injuries of the tibiotalar and subtalar joints, a patient with tuberculosis of the tibiotalar and subtalar joints, and two patients with pain following astragalectomy for flail-foot due to poliomyelitis.

Dr. Lewis Clark Wagner [62], in his discussion, stated that he prefers to use the anterior approach for a two-stage panarthrodesis, but he considers the posterior arthrodesis indicated for the correction of old calcaneus deformities following astragalectomy and for quiescent tuberculosis in long-infected joints. In his opinion adequate bone for the graft can be obtained from the tibia.

The Pathology, Diagnosis, and Treatment of Extra-Abdominal Desmoid Tumors. Dr. R. H. Ramsey [63] called attention to a group of benign fibrous-tissue lesions which must be differentiated from fibrosarcomata in order to avoid unnecessarily radical treatment. These have been classified by Stout under the heading of fibromatoses and include fibromata, keloids, desmoids, penile fibromatosis, plantar fibromatosis and palmar fibromatosis (Dupuytren's), fibromatosis colli (congenital torticollis), progressive myositis fibrosa, and irradiation fibromatosis. All of these are essentially benign and self-limited. Special care must be taken to distinguish between irradiation fibromatosis which is definitely a premalignant lesion and fibrosarcoma. Desmoid tumors and plantar fibromatosis and palmar fibromatosis do not become malignant.

Accurate diagnosis is the *sine qua non;* this is possible by means of study of representative tissue obtained by biopsy. Wide excision biopsy can be done only if the lesion is small and conveniently located.

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Endocrine factors are at play in these lesions but are not well indicated. Regression of an inoperable abdominal desmoid followed irradiation castration. Estrogenic substances have been shown experimentally to be fibromatogenic; synthetic progesterone is antifibromatogenic in guinea pigs.

Grossly, desmoids are in close association with musculo-aponeurotic tissues. The tumor is yellowish-white, firm, and lobulated. The borders are irregular, devoid of capsule, and invasive.

Microscopically, collagenous fibrous tissue predominates with but moderate cellularity. The cells are typical fibrocytes and are uniform in size and shape. Mitotic figures are rare; there are no pathological mitoses.

Fibrosarcoma, in contrast, shows a strong tendency to encapsulation and is far more cellular. Mitotic figures are frequent; some of these are atypical.

Radical local excision of the desmoid tumor is the treatment of choice. Recurrence is common; further radical excision is done. Close association with nerves, muscles, and large vessels makes excision of the desmoid less radical; mutilation is hardly ever necessary.

Experimental and Clinical Use of Bone Milled in the Kitchen Blender. Dr. Norman J. Rosenberg [64], Dr. Rudolph S. Reich [65], and Dr. Malcolm Brahms [66] presented a method for reducing bone-graft material to particles ranging from a few micra to one or two millimeters in diameter. This is accomplished by means of an ordinary kitchen blender (liquidizer or osterizer) which can be sterilized and used at the operating table. Metal blades spin in the bottom of the sterile container which contains chilled normal saline solution. Pieces of cortical or cancellous bone are reduced to particles of the desired size within five minutes. The authors believe that the grinding and washing of the bone destroys all of the osteocytes but does not alter the organic or crystalline components.

The use of this method is based upon the assumption that all of the osteogenic activity at the site of a bone graft arises from the host tissues and that the graft merely provides available calcium and phosphorus and stimulates osteogenesis on the part of the host. Therefore, it is desirable that a bone graft present the greatest possible surface area to the host tissue; this is accomplished best by reducing the graft material to the smallest visible particles.

The authors have studied the behavior of blenderized bone transplants in mature dogs, the femora and humeri being used. A comparison was made of the response called forth at the host site by the implantation of fresh autogenous bone, frozen autogenous bone, frozen homogenous bone, and the larger particles of autogenous bone afforded by drill shavings. The various sites were studied at intervals of fourteen, twenty-one, and twenty-eight days after the bone-grafting operation. No difference was found in the behavior of blenderized cortical bone as compared with similarly treated cancellous bone. The small particles of bone were more rapidly incorporated into the host than were the drill shavings. Homogenous bone particles called forth a greater response of fibrous tissue and less osteoid tissue than those which resulted from the implantation of autogenous bone. Healing of the defect in which homogenous bone had been implanted was slower than it was with autogenous bone.

A series of clinical cases was presented in which twenty-nine operations had been performed with blenderized frozen homogenous bone, and twelve operations had been done with blenderized autogenous bone. There were three failures. In one autogenous bone had been used following the excision of a giant-cell tumor, in one homogenous bone had been used in an osteomyelitic cavity, and in the third homogenous bone had been used in lumbosacral fusion.

Dr. Frederic C. Bost [67] pointed out that small pieces of cancellous bone when used as graft material permit earlier and more extensive revascularization than large masses and a relatively greater surface area. He felt that the gradual filling of large defects with the blenderized grafts had certain advantages over filling the whole cavity at once.

Dr. George J. Garceau [68] said that he had used the blenderized bone for grafting and that he liked it.

Experiences with Poliomyelitic Scoliosis after Fusion and Correction. Dr. Thomas Gucker, III [69], in a series of eighty-eight patients with paralytic scoliosis, who had been treated by spine fusion, presented an analysis of the amount of correction obtained during postoperative recumbent immobilization and the subsequent changes occurring after the resumption of sitting and standing. The majority had not been treated by corrective wedging preoperatively. Surgery was carried out in stages, four to five intervertebral spaces being fused at each surgical session. Postoperatively, for about ten days after the last stage, the corseted patient was recumbent on a firm mattress over a bed board. A hinged turnbuckle cast was then applied and correction was obtained within a few weeks; in thirteen patients with extensive or high thoracic curves,

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the Milwaukee frame was used. After three to four months of recumbency, the plaster jacket was removed and a cellulose-acetate jacket was applied and was worn for the remainder of the first year after operation, when it was replaced by a corset. In the seventy-eight patients who were examined after an average follow-up period of four and one-half years postoperatively, the scoliotic curve had progressed in 9 per cent., had not changed in 47 per cent., and had been improved in 44 per cent. Of the 56 per cent. in whom pseudarthrosis developed, only 13 per cent. had pain and only 18 per cent. were re-operated upon. In these the loss of initial correction was greater following the first six-month period of sitting and standing and was greatest after one year. For this reason it was felt that four months of recumbent immobilization was sufficient, but that the cellulose-acetate jacket should be worn for two years thereafter. From this analysis, the impression was gained that practically no type of apparatus worn in the erect attitude can correct a structural paralytic scoliosis, that fusion in a patient as young as ten years of age need not result unfavorably, that at surgery the spinous processes should be removed to allow closer contact of the strip grafts to the underlying decorticated laminal bed, and that, when pseudarthrosis has been discovered and the loss of correction has been determined from roentgenograms made with the patient recumbent in the position of extreme lateral bending, surgery should be advised if the pseudarthrosis is great and if definite hypermobility is present. If the loss of correction is still commensurate with a satisfactory outcome, the patient should be instructed to limit the time spent in the erect position; and, at two-month intervals, anteroposterior and oblique roentgenograms should be made until loss of correction has ceased. In only four patients with pseudarthrosis did the loss of correction require surgical intervention.

Dr. John H. Moe [70], in discussing paralytic scoliosis, re-emphasized the need for improving results. He feels, however, that the patient's cosmetic functional improvement is the first consideration; x-ray measurements can be misleading. Progressive deformity should be promptly treated by correction and fusion at the age in which it occurs. To delay is to lose the golden opportunity. However, he feels that a longer rather than a shorter area should be fused. Seldom, if ever, does bending occur in a fused curve. Failure to hold correction means pseudarthrosis. Most pseudarthroses can be detected by carefully made oblique roentgenograms. He felt that a meticulous fusion technique is indispensable if success is to be achieved. His own experience had been dramatic. By including careful fusion of the posterior articulations in his technique, his percentage of failure had dropped from about 50 per cent. to less than 10 per cent. His percentages were based on an experience which included 225 fusions in scoliotic spines.

Dr. Joseph C. Risser [71] made a strong plea for early fusion in paralytic scoliosis. He emphasized that fusion should be promptly undertaken before deformity becomes severe. However, before fusion is done, correction must be obtained; otherwise, the area to be fused cannot be properly evaluated. Furthermore, corrections must be maintained until the fusion is fully adequate and is equal to the task of maintaining the correction unaided. Time limits cannot, therefore, be set; jackets must be worn until the fusion is adequate. He felt that fusion of the posterior articulations as part of the over-all fusion was indispensable; the closer the fusion is done to the point of contact between the vertebrae, the better have been his results. This point was stressed years ago by Dr. Hibbs.

Tibial Condylar Fractures. A Clinical and Experimental Study. Dr. Mason Hohl [72] and Dr. J. Vernon Luck [8] sought to determine the indications for conservative and operative treatment of fractures of a tibial condyle through an analysis of 227 cases which had an adequate follow-up. Additional conclusions were drawn from experiments performed upon both knees of six monkeys in which defects in the tibial or femoral condyles had been created and in which the healing process was studied in relation to the effect of immobilization.

Fractures of the tibial condyle were classified as undisplaced (25 per cent.) and displaced (75 per cent.). The latter were further subdivided into local depression fractures (48 per cent.), total condyle depression fractures (18 per cent.), and split fractures (7 per cent.). An open reduction had been performed in forty-four of the 227 patients who were followed for two to thirteen years. The results in the cases of undisplaced fracture (treated by plaster immobilization for four weeks or less followed by non-weight-bearing exercises thereafter and full weight-bearing in three months) were uniformly good.

The functional results in displaced fractures were not closely related to the anatomical results. For example, the 132 cases of local condylar depression which had been primarily treated in long casts showed unacceptable anatomical results (due to valgus deformity in 40 per cent.) in 98 per cent. of the series. In contrast, the functional results were usually satisfactory regardless of the type of treatment, providing there had been early mobilization of the knee. It was emphasized that the open reduction of a locally depressed fracture is indicated when the displacement exceeds one centimeter and when valgus deformity would be objectionable.

The forty-seven cases of total condyle depression, most of which had been treated by manipulation under anaesthesia, showed uniformly poor anatomical results, with unstable joints, and valgus or varus deformity. Nevertheless, acceptable functional results were obtained in 79 per cent. of these patients. The use of manipulation followed by skeletal traction in this type of injury, with open reduction and adequate internal fixation

[70] 825 Nicollet Avenue, Minneapolis 2, Minnesota.
[71] 2637 East Washington Street, Pasadena 8, California.
[72] 9730 Wilshire Boulevard, Beverly Hills, California.

if these were necessary to secure anatomical correction, was recommended. There were nineteen split fractures. Fourteen of these had been treated conservatively; functional results were acceptable in nine. Five had been treated surgically; satisfactory results were obtained in three.

It was concluded that the age of the patient made no significant difference in the functional result and that cast immobilization for prolonged periods of time did not prevent the development of late valgus or varus deformity. Degenerative joint changes were noted more frequently in patients with residual varus or valgus deformity, although the depth of the depression in a displaced fracture was not related to the subsequent development of degenerative joint changes.

Experiments had been performed on six monkeys in which defects were created in the tibial condyles or the femoral condyles of both knees, one of the knees being immobilized in plaster for two or three months after the operation. Intramuscular injections of cortisone were used in two animals.

In the absence of immobilization, the femoral and tibial defects healed rapidly without the formation of adhesions. Immobilization of knees with femoral defects resulted in the formation of heavy adhesions, although knees with defects in the tibial condyle showed less tendency to the formation of adhesions. Cortisone, injected intramuscularly, had no influence on healing or on adhesion formation in the two animals in which it had been used.

The defects in the condyles of the femur or the tibia had healed by the ingrowth of fibrous tissue which had gradually been transformed into fibrocartilage and, to some degree, into hyaline cartilage in the areas subjected to pressure during joint motion. The functional use of the joint is essential to such a transformation. Prolonged immobilization causes pannus formation and heavy adhesions, the condition being designated clinically as "traumatic arthrofibrosis". This condition is to be distinguished from the traumatic osteoarthritis which follows damage to the articular cartilage of a joint which has remained active.

It was emphasized in conclusion that "early active motion is most important in obtaining optimum results in tibial condylar fractures".

SCIENTIFIC EXHIBITS

The Scientific Exhibits were of unusually high quality; they were very popular and were well attended. Summaries of the Exhibits follow:

Hereditary Ochronosis. A Key to the Etiology of Synovial Osteochondromatosis. Dr. Carl E. Anderson of the University of California, San Francisco, California, showed that hereditary ochronosis is an inborn error of amino-acid metabolism with an abnormal terminal metabolite which pigments and destroys articular cartilage in the major weight-bearing joints. It causes severe specific arthritis and spondylitis.

Three new cases of this disorder were presented and the occurrence of synovial osteochrondromatosis in the knee joints was noted. The osteochondromatosis appeared to be related to the deposition of fragments of dead articular cartilage in the synovial membrane.

Healing of Ununited Stabilized Fractures Reinforced with Iliac Bone. Dr. Carl E. Badgley, Dr. Sylvester J. O'Connor, and Dr. Hobart E. Klaaren of the University of Michigan, Ann Arbor, Michigan, presented cases to illustrate a conservative surgical procedure for a specific group of ununited fractures. Initially the technique had been employed for ununited fractures of the tibia with an intact fibula and satisfactory alignment. The success of this method had led to its use in non-union of fractures of the long bones which had satisfactory alignment and some security of fixation by fibrous tissue. Later, this technique had been utilized in the treatment of severe Y-shaped or T-shaped fractures of the distal end of the femur. Traction for five weeks had preceded the surgical procedure in the latter group.

The technique had been developed and expanded over twenty-two years. The original method had included excision of the dense fragment ends of the tibia, while the posterior soft tissue had been saved to maintain stability. The interval had been filled with cortical chips and massive grafts had been placed on either side. Abbott's work demonstrating the superiority of iliac grafts for bone healing had led to the substitution of iliac bone for use between the bone ends and as lateral grafts. The technique of reinforcement by iliac bone of poorly or partially healed fractures of the shaft of the bone used in the Army in the last War had been an added incentive to the extension of this technique to ununited fractures of single long bones.

This, it is believed, is a physiological method; it saves the patient time and requires minimal operation without much loss of the healing already gained. The technique can be summarized as follows: The fracture site is exposed with as little disturbance of the bone ends as possible. The cortex and soft-tissue attachments on either side of the shaft are cut with an osteotome to bleeding cortical bone. Through an adequate window, the tissue interposed between the bone ends is removed. The bone ends are drilled in order to open the medullary canal. The space between the bone ends and the medullary canal is filled with cancellous iliac bone. The

iliac grafts are so prepared that they extend well above and well below the abnormal bone and are fixed with screws to the host fragments, with the cortical bone of the graft on the outside. The wound is closed without other internal fixation and a plaster cast is applied.

In the authors' experience, this method has been virtually universally successful. In twenty years there were two failures, one of which eventually healed after a massive tibial graft had been applied. The second failure was in the lower end of the femur in a patient with an ankylosed knee following osteomyelitis of the lower end of the femur. The shaft of the bone appeared to be dense and in poor condition at the time of operation. Two surgical procedures failed. Intramedullary fixation might have been successful.

This conservative technical procedure has saved weeks of healing time, has preserved the healing already present, and has been successful in treatment of the specified types of fractures.

Progress in Upper-Extremity Prosthetics. Dr. C. O. Bechtol, Dr. Paul E. McMaster, Dr. Robert Mazet, Jr., Dr. Craig L. Taylor, and Dr. M. Anderson of the University of California, Los Angeles, California, re-emphasized that new mechanical devices are available which replace most of the normal functional anatomy of the arm and which greatly increase the usefulness of modern upper-extremity prostheses. These devices are based on fundamental research done under the guidance of Dr. Craig L. Taylor in the Department of Engineering Research, University of California, Los Angeles. As a result, there are no longer any sites of election for amputation in the upper extremity, since the necessary mechanical replacements for the lost human part are available for any level of amputation. It has been found, through careful case studies, that all possible length should be saved in any amputation. Saving of additional length leads to an improvement in function of the amputee. The previously undesirable areas of amputation immediately about the shoulder, elbow, and wrist joints can now be used and the stumps can be suitably fitted.

The various prosthetic devices are also available in sizes for children. At present, the general rule is to fit child arm amputees at the age of about four. However, they feel that future research in fitting and training of the younger child will reduce this age considerably.

The Central Office of The American Academy of Orthopaedic Surgeons, Inc., Chicago, was placed at the service of the membership through a booth in one of the main corridors and proved most helpful.

Diagnostic Problems in Children's Orthopaedics, presented by the Committee on Pathology of The American Academy of Orthopaedic Surgeons, was of interest and value.

Craig Vertebral-Body Biopsy Kit. Dr. Frederick S. Craig of the New York Orthopaedic Hospital at Columbia-Presbyterian Medical Center, New York, N. Y., demonstrated a new vertebral-body biopsy kit consisting of an infiltration needle, a cannula into which fits closely a trochar which is blunted in order to avoid nerve penetration, and two cutters. Necessary accessories were a blunt stylette with which the tissues are palpated before the cutter and with which the core is expressed. A sharp worm with which cancerous tissue and disc tissue are extracted is also included. Anatomical cross-section drawings and an articulated spinal column were used to demonstrate the technique. X-rays of approaches to the cervical, thoracic, and upper and lower lumbar regions were shown as typical diagnostic problems. Biopsy specimens of disc and vertebral-body tissues were shown. Three sclerotic vertebrae were demonstrated to illustrate the effects of thyroid metastasis, of tuberculosis, and of asceptic necrosis. All diagnoses had been verified by biopsy done under local anaesthesia.

Transarticular Fixation of Intra-Articular Fractures. Lt. Col. Ernst Dehne, Capt. Robert E. Feighny, and Maj. John J. Keys, of Letterman Army Hospital, San Francisco, California, exhibited a method of transarticular fixation which is based on the presumption that such fractures have mechanical and biological disadvantages. The transfixation is designed to improve the mechanical factors. One complication was described which strongly indicates the inadequacy of the orthodox method of immobilization.

The exhibit was based on a study of twenty-five cases of fracture of the carpal navicular (scaphoid), one case of fracture-dislocation of the talus, and one case of infected non-union of the hip. The method of treatment of the fractured navicular consisted in the insertion of a Kirschner wire through the thenar eminence, through the greater multangular, and through both fragments of the navicular into the radius. The wire was clipped off subcutaneously, and the wrists were immobilized in skin-tight casts extending from the elbow to the distal joint of the thumb.

In fourteen non-unions of fractures of the navicular, bony union was obtained in nine within four to seven months; five were still under treatment. Some of the fractures had not previously responded to prolonged immobilization in plaster casts. Of nine cases of avascular necrosis of the proximal fragment, bony union occurred in all. In five of these, complete revascularization occurred within six months; in the remaining four, bony union occurred but immobilization was continued, pending completion of the revascularization. The only complication noted was migration or breakage of the wires; this occurred in 50 per cent. of the

patients in spite of plaster immobilization. This was interpreted as an indication that orthodox plaster immobilization does not prevent motion of the wrist. Bony union was obtained both in a fracture-dislocation of the talus and in a non-union of the hip; this suggested that the method can be applied to advantage in joints other than those in the wrist.

Sciatic-Tension Test. Dr. W. Minor Deyerle [1] and Dr. Virgil R. May, Jr.[2], showed a test which differentiates between root compression and other causes of back and leg pain.

The patient is instructed to sit on the edge of the examining table, holding his back and head straight, bracing with the hands at his sides. The knees dangle over the side of the table. The patient is instructed not to move his back or any portion of his body during the test. The examiner extends the limb on the affected side at the knee until the patient states that the leg pain, or a portion of the pain, is reproduced. The leg is lowered just below the point of pain, and the examiner clasps the foot between his knees and holds the knee with both hands. With the leg in this fixed position, the examiner's fingers, which are resting lightly over the popliteal space, can be made to press directly into the center of the popliteal space. The slight local discomfort of this pressure is greatly overshadowed by the severe reproduction of the patient's pain. Since nothing else is moved during the time of the test except the pressure over the tense bowstring nerve, nerve-root compression is indicated as the causative agent in any pain so produced.

In borderline cases, the test may be made even more sensitive by means of dorsiflexing the foot and flexing the head before starting. The test is more accurate and more selective than straight-leg-raising tests which involve motion at the hip, knee, and ankle joints at the time of the test for pain.

Serum Anti-Enzymes in Bone Disease. Dr. Richard H. Hall of the Veterans Administration Hospital, Long Beach, California, demonstrated that the enzyme pattern is a simple laboratory test which is useful in orthopaedic diagnosis. This test aids in determining the activity of tuberculous bone or joint disease; it helps to differentiate benign from malignant non-myeloid primary bone tumors; and it aids in the over-all presurgical evaluation of the chronically ill.

Studies in Massive Bone Transplantation. Dr. Charles H. Herndon [3], Dr. Paul H. Curtiss, Jr. [4], and Dr. Samuel W. Chase [5] had found marked differences in the results of transplantation of whole autogenous knee joints when these were compared with the results of the transplantation of direct or delayed whole homogenous knee joints. In the former, some of the cells remained viable after transplantation, the bone being rapidly revascularized and the dead bone being replaced with new bone. In the latter, all of the cells in the delayed homogenous transplants and most of the cells in the direct homogenous transplants died. Revascularization and active osteogenesis were slow, and marked degenerative changes began between four and six months after transplantation. The cause of this difference is not known, but it may be related to a type-specific physical-chemical structure of bone.

Investigation of the possible relationship of blood groups to homogenous bone-grafting was studied by the implantation of bone into the back muscles of rabbits from dogs in which the red blood cells contained the "canine A factor". Higher agglutinin patterns developed in the rabbits, but the specificity of this agglutinin over the "canine A factors" was not proved by adsorption. Transplantation of a whole knee joint from an "A-positive" dog into an "A-negative" dog resulted in the development of low titer agglutinins in two of five dogs. Adsorption tests indicated the possible specificity of this agglutinin for the "canine A factor" in the red blood cells of the donor dogs. The grafting of iliac bone into ulnar defects was done in a series of ten pairs of "A-negative" and "A-positive" dogs, the former being injected preoperatively with "A-positive" red blood cells from the latter until an "anti-A" agglutinin titer of at least one to 256 was reached. Each dog had received (1) an autogenous graft, (2) a homogenous blood-type-incompatible graft, and (3) a homogenous blood-type-compatible graft. It was found that known incompatibility of blood types had no demonstrable histological effect on the healing of homogenous or autogenous iliac-bone grafts in the dog. Autogenous grafts showed consistently better response than did either type of homogenous bone graft.

Splint for Treatment of Congenital Dislocation and Dysplasia of the Hip. Dr. Frederic W. Ilfeld of the Children's Hospital, Los Angeles, California, demonstrated an adjustable thigh splint with a pelvic band which he had used on eighty-six patients. The importance of early diagnosis and the advantages of this simple inexpensive device were emphasized. In thirty-four patients with congenital dislocation of the hip, the splint method had been used as the primary treatment; in twenty-six patients the splint had been applied after a plaster cast had been worn to supplement closed or open reduction of the hip; and, in nineteen patients with dysplasia of the hip, the splint had been worn only at night. Internal rotation

[1] 2222 Monument Avenue, Richmond 20, Virginia.
[2] 2222 Monument Avenue, Richmond 20, Virginia.
[3] 2065 Adelbert Road, Cleveland 6, Ohio.
[4] 2065 Adelbert Road, Cleveland 6, Ohio.
[5] 2065 Adelbert Road, Cleveland 6, Ohio.

may be obtained by the use of an "outrigger" attachment to the splint; this was effective in five patients with anteversion of the femoral neck. The splint had failed to be effective in a spastic child, but it had improved hip motions in a patient after a Colonna hip-reconstruction operation.

The splint is composed of thigh cuffs connected with an adjustable crossbar by a universal joint which may be locked in place with a hexagonal wrench. The wrench is retained by the surgeon in order to prevent home adjustment. In addition, the thigh bands are connected by a right-angle joint with stops to allow motion through 90 degrees; this enables the patient to sit or to lie down. The pelvis is free, and easy perineal care and motion at the hips are thus permitted. The patient may crawl, sit, or walk in the splint. The normal kicking motions and use of the good limb are unimpeded. Gradual abduction is obtained without excessive force. The splint is adjustable to accommodate for changes in adductor spasm and growth.

With the use of the splint as primary treatment of congenital dislocation of the hip, excellent clinical results were obtained in thirty-one patients (91 per cent.); slight abduction contracture or flexion contracture resulted in three (9 per cent.). The roentgenographic appearance of the hip was normal in twenty-six patients (76 per cent.); moderate deformity was present in three (9 per cent.) and aseptic necrosis occurred in five (15 per cent.). The average age of these patients was seven months, the youngest was one and a half months and the oldest was nineteen months. The splint was worn full time for about four and a half months and part time at night for another four and a half months. The average follow-up was fifteen months, the least being three months and the longest being forty-one months. In the twenty-six patients in whom the splint had been used to supplement previous closed or open reduction of the hip and plaster immobilization, the hip as seen roentgenographically was normal in sixteen (61 per cent.), there was moderate deformity in ten (38 per cent.), and there was aseptic necrosis in nine (34 per cent.). One patient had redislocation in the splint which required a second reduction. The average age in this group was seventeen months. The splint was used as a supplement to plaster immobilization as early as five weeks and as late as thirty-one months. It was worn full time for an average of six and a half months and part time for six months. In this manner, the splint shortened the length of time of plaster immobilization and aided in the seating of the femoral head in the acetabulum and in the development of the acetabulum. An adaptation of the splint had been used successfully on four dogs with dysplasia of the hip.

Motorist Injuries. Dr. Jacob Kulowski[6] presented an epidemiological approach to the problem of motorist injuries and depicted the interactions during the accident between the automobile occupants, the automobile, and the environment. On the clinical side, 528 motorist casualties (presenting 1,413 injuries) were graphically analyzed as to the type of injury, the severity of injury, the body areas involved, and the mortality rate. The latter was derived from a small group of dangerously injured persons; the clinical implications of the mortality rate were surprising.

A second feature of the exhibit pertained to such predisposing factors to injury as force, collapse of structure, relation to impact areas, and general and local body tolerances to impact or the force of inertia (the limits of the factors of safety of the human body). Special emphasis was devoted to the great magnitude of the forces involved and their brief duration.

Further responsibilities of medical groups were mentioned.

Suggestions for increasing occupant safety under crash conditions included the three R's: reduction of top speeds, revision of the interior design of the occupants' compartment, and safety restraint of the occupants by means of a safety belt.

The Rehabilitation Center—Its Role in Recovery. The Liberty Mutual Insurance Company, W. Scott Allan, Supervisor, Boston, Massachusetts, in the exhibit emphasized that the rehabilitation center acts as a supplement to the care rendered by the attending physician and bridges the gap between the hospital and the return to work with an individualized program directed at maximum recovery of function and adjustment to physical handicap. A coordinated program of therapy, testing, and counseling, all under medical supervision, provides an effective method of reducing loss in the industrial accident case. As a working tool, the center becomes an integral part of the community medical and health services interested in the restoration of the individual to an effective physical, social, and economic whole.

The attending physician, the hospital, private health agencies, public rehabilitation agencies, vocational training schools, and industrial medical programs can all utilize the services of a rehabilitation center in providing the comprehensive care which is the medium for complete restoration of the patient. Understanding and coordination of effort is imperative to success. The specific services rendered in the rehabilitation center must include (1) complete physical examination, (2) diagnostic review and therapy prescription, (3) orientation and counseling, (4) occupational therapy, (5) aptitude testing, (6) job placement, (7) prosthetic service, and (8) physical therapy.

Two case histories were presented of typical industrial injuries; these patients were materially improved by the program of the rehabilitation center:

[6] 414 Corby Building, St. Joseph, Missouri.

A male, thirty-one years old, who was employed as a porter, had caught his left hand and forearm in the ram of a paper-baling machine and had sustained severe lacerations of wrist tendons and crushing of all the bony structures of the left hand. Amputation was performed at the junction of the middle and lower thirds of the left forearm, with subsequent surgical revision of the stump. He was admitted to the Center twenty-four weeks following injury, spent five weeks in the center program, and returned to work at his regular employment thirty weeks after the date of injury. Proper fitting and training in the use of the prosthesis, together with the concentrated therapy program, made it possible for him to return to his regular job, sooner than would otherwise have been the case, with an excellent adjustment to his disability.

A male, fifty-three years old, who was employed as a marine engineer had been injured when the steel wire on a winch snapped and coiled around his right arm, pulling it into the winch. He sustained a compound fracture of the right radius and ulna which had been fixed with skeletal-traction pins at the wrist and elbow. The fractures subsequently required open reduction and grafting. He was admitted to the Center eight weeks following injury, spent seventeen weeks in the Center program, and returned to his regular job twenty-five weeks after the date of injury. Early and adequate follow-up on treatment and surgery, as well as the concentrated therapy program, materially reduced his temporary disability and resulted in no permanent loss of function of the arm or the hand.

The Late Effects of Internally Deposited Radio-Active Materials. Lt. W. B. Looney and Lt., j.g., M. Colodzin of the United States Naval Hospital, National Naval Medical Center, Bethesda, Maryland, made four investigations of the late effects of internally deposited radio-active materials. The investigation of the late effects of radium salts given orally and intravenously to fifty patients therapeutically and the effects of radium in twenty-eight patients employed as luminous-dial workers was made at Harvard Medical School, the Argonne National Laboratory, and the Massachusetts Institute of Technology. The investigation of the late effects of thorotrast in 250 patients was made at the Finsen Institute, Copenhagen, Denmark, and at the National Naval Medical Center, in conjunction with the Universities of Utah and Rochester.

A summary of the clinical, histopathological, autoradiographic, roentgenographic, and radiochemical findings was presented. Emphasis was placed on the clinical findings that may aid in the diagnosis of internally deposited radio-active materials. The importance of the data obtained from these patients for the more adequate protection of the increasing numbers of our population who will be exposed to radio-activity was stressed.

Mechanical Complications Attending Internal Fixation of Fractures and Their Sequelae. Dr. Theodore A. Lynn [7] and Dr. Richard McAtee [8] designed an exhibit to point out the frightening complications that can be incurred through surgical endeavors which on critical analysis prove not to complement Nature's healing processes but rather to inhibit them. Examples of each of the more common errors encountered were shown. Particularly impressive was the frequent failure in healing of fractures treated by internal fixation with a variety of appliances.

Manipulative Treatment of Herniation of the Lumbar Intervertebral Disc. An End-Result Study of 205 Cases. Dr. Merrill C. Mensor [9] presented a statistical survey of a series of patients with a ten-year follow-up in whom sufficient clinical signs and symptoms were disclosed to warrant a presumptive diagnosis of herniation of the lumbar intervertebral disc. The series was subdivided into private and industrial cases. A uniform regimen of therapy was followed throughout in order to obtain optimum analytical data. The point was stressed that manipulation is only one important phase of the conservative treatment, and, in order to obtain satisfactory results, all phases of the therapy are important.

Treatment consisted in bilateral leg traction in the "contour position", manipulation of the back under pentothal sodium anaesthesia, temporary brace support, and rehabilitation flexion exercises.

Statistical charts illustrating the clinical findings, the method of manipulation and traction, the end results, and comparisons between operative and non-operative cases, as well as between private and industrial cases, were presented.

This data disclosed satisfactory results in 64 per cent. of the private patients and in 45 per cent. of the industrial patients. Failure of conservative therapy resulted in a recommendation for surgical intervention and 27 per cent. were operated upon.

It was concluded from the analysis that the conservative regimen followed gives a sufficiently high percentage of satisfactory results to warrant its trial before surgical intervention is considered.

Insertion of Multiple Nails in Femoral-Neck Fractures. Dr. Michael T. Modney and Dr. Harold G. Kunz of the Mountainside Hospital, Montclair, New Jersey, presented the technique of parallel insertion

[7] 1047 Gayley Avenue, Los Angeles 24, California.
[8] Los Angeles, California.
[9] 490 Post Street, San Francisco 2, California.

of four Austin Moore nails by the use of a simple mechanical guide. Photographs and x-rays of twelve patients with fracture of the femoral neck so treated were shown. With the help of a guide, the widely spaced nails were placed in the periphery of the femoral neck. These engaged the calcar femorale and the denser bone of the periphery of the neck and assured impaction at the fracture site without torsion, rotation, or varus slipping of the femoral head. When the nails have been properly placed, the method conforms to good engineering principles for the adequate fixation of intracapsular fractures. Bony union occurred in all cases in the series. No evidence of aseptic necrosis had been observed in the short follow-up period of eighteen months.

X-Ray Standards in Orthopaedics. Dr. Alonzo J. Neufeld and Dr. Malcolm B. Downs of the College of Medical Evangelists, Loma Linda and Los Angeles, California, showed that the resolution of the human eye is approximately 0.1 millimeter. X-rays can now be produced which will approach this degree of resolution in many instances. In this exhibit, serial x-rays were shown to demonstrate that, with the use of a small focal spot x-ray tube (0.3 millimeter), the sharpness or resolution approaches or equals that of the human eye when the object is no further than twelve inches from the plate with a standard thirty-six-inch tube distance. This is true with non-screen film. When intensifying screens are used, an unsharpness of approximately 0.3 millimeter is introduced. In order to maintain the resolution referred to as the ideal or standard, a tube with a focal spot of not over 0.5 millimeter would be required. In order to meet the best standards of x-ray technique today, roentgenograms of all extremities, including the knee and shoulder joints, should be made with non-screen film and a Buckey diaphragm, with the smallest focal spot available. Present limitations of equipment still do not permit us to make satisfactory lateral roentgenograms of the lumbar spine.

Compression Neuropathy of the Median Nerve in the Carpal Tunnel. Dr. George S. Phalen and Dr. James I. Kendrick of the Cleveland Clinic, Cleveland, Ohio, emphasized that numbness and tingling in the median distribution in the hand may be due to compression of the median nerve against the transverse carpal ligament. The diagnosis of this condition is made by the presence of the Tinel sign over the median nerve at the wrist, sensory changes restricted to the median distribution distal to the wrist, and an accentuation of the patient's symptoms by sustained flexion of the wrist. Thenar atrophy may also be present.

Section of the transverse carpal ligament is the simplest method of decompressing the median nerve. Excision of the synovial membrane of the flexor tendon sheath may also be necessary occasionally.

The exhibit was based on a series of forty-five patients; twenty-six of the patients had bilateral symptoms, and twenty-two showed some degree of thenar atrophy. Thirty-seven of the forty-five were women. Over half of the patients had had symptoms for two years or more; and the majority of the patients were from forty to sixty years of age.

The transverse carpal ligament was sectioned in thirty-eight wrists in twenty-nine patients. At operation, obvious swelling and compression of the median nerve was noted, together with thickening of the synovial membrane of the common flexor tendon sheath in most patients. All the patients were relieved of pain, and most regained normal sensation in their hands. Thenar atrophy of more than one year's duration was not improved by surgery.

A New Punch-Biopsy Technique for Diagnosis of Joint Disease. Dr. William H. Bickel, Dr. Howard F. Polley, and Dr. Malcolm B. Dockerty of the Mayo Clinic and Mayo Foundation, Rochester, Minnesota, presented an instrument for punch biopsy of the synovial membrane. The procedure is relatively easy, can be performed on ambulatory or hospitalized patients with either local or general anaesthesia, and avoids the morbidity incidental to examination by arthrotomy.

The diagnosis of joint disease has been facilitated by use of this punch biopsy. Single or repeated examinations have been performed on 334 joints in 275 patients. The knee is the most suitable joint for punch biopsy, but the ankle, elbow, and shoulder have also been successfully examined by means of this technique.

Included in the exhibit were: (1) anatomical models, photographs, and descriptions of the technique of synovial biopsy; (2) case reports, photographs, roentgenograms, and photomicrographs, illustrating the value of the punch-biopsy technique in the differential diagnosis of articular diseases; and (3) comparison of synovial specimens obtained by punch biopsy and arthrotomy and a demonstration of the usefulness of a punch-biopsy technique in the study of pathological conditions of the synovial membrane at stages in rheumatic disease with articular manifestations and in the evaluation of therapy.

Legg-Perthes Disease and Physical Development. Dr. Edgar L. Ralston, from the Children's Seashore House of Atlantic City, Atlantic City, New Jersey, exhibited a study of seventy-two patients with active Legg-Perthes disease and suggested that there is a certain lag in the physical development in these patients. There is usually a lag in bone age in relation to chronological age. This averaged two years in boys and was not apparent in girls. The height and weight of these patients usually fell low on the standard tables. When the height and the weight have been plotted on the Wetzel grid, some improvement is noted during the convalescent phase. All determinations of the serum-protein-bound iodine were within normal limits.

The Effect of Compression on the Growth of Epiphyseal Bone. Dr. L. J. Strobino, Dr. Paul C. Colonna, Dr. George O. French, and Dr. R. S. Brodey from the University of Pennsylvania, Philadelphia, presented evidence in support of three fundamental conclusions which they had drawn from experiments which had been performed on calves.

1. Epiphyseal bone follows an "all-or-none" law of growth to a point which is far beyond any physiological value expected with respect to compressive force exerted against it.

2. The force exerted by the proximal tibial epiphysis of the calf is a little less than the total weight of the animal as was shown by the reading of 340 pounds which was necessary to produce epiphyseal arrest. This force is equal to approximately forty-five pounds per square inch on a cross section.

3. The growth of the epiphyseal plate in calves had been arrested for a protracted period of time. An arrest of six months' duration is equal to three or four years in a human patient. In these calves, the epiphyseal plate remained viable during this period; thereafter growth was resumed in it at an accelerated rate which was sufficient to produce equalization of bone length (2.8 centimeters).

Bone Changes in the Blood Dyscrasias. Dr. Arthur A. Thibodeau and Dr. Joseph K. Maloy. Tufts College Medical School and the New England Medical Center, Boston, Massachusetts. No abstract submitted.

Chondrosarcoma of the Proximal Femur Treated by Resection and Bone Replacement. A Five-Year Result. Dr. Vernon P. Thompson and Dr. Clair T. Steggall of Los Angeles General Hospital, Department of Surgery (Orthopaedics), University of Southern California School of Medicine, Los Angeles, California, presented an exhibit which consisted of roentgenograms and photomicrographic and operative color transparencies illustrating the case history of a twenty-year-old woman with chondrosarcoma of the head, neck, and intertrochanteric region of the femur. The proximal two-fifths of the femur had been resected, the head and neck had been removed, and the remaining bony specimen had been autoclaved and had been replaced as a graft. Union to the shaft had occurred early. A pathological intertrochanteric fracture occurred later; this was treated by the application of a fresh autogenous tibial graft. Union of the graft occurred early. Full weight-bearing was allowed in two and a half years. Roentgenograms made five years later showed the new, strong, and mature architecture of the arthrodesed hip and the proximal shaft of the femur. There was no evidence of recurrence.

Problem Cases of Prosthetic Replacement of the Hip Joint. Dr. J. E. M. Thomson, Dr. C. F. Ferciot, Dr. W. W. Bartels, Dr. F. S. Webster, and Dr. Paul Goetowski of the Lincoln Orthopaedic Clinic, Lincoln, Nebraska, presented an analysis of 161 patients who had been operated upon during the past six years and in whom the J. E. M. Thomson "light-bulb" prosthesis, or a modification of it, had been inserted. Thirty-eight of the patients suffered complications which had unfavorably influenced the result. In a number of patients there was more than one complication.

The operation had been complicated preoperatively in seven patients by hemiplegia. In two patients, there was healed hip-joint infection, and in six patients there was disabling arthritis in other joints. There were two cases of senile dementia and one of Hodgkin's disease.

Among the thirty postoperative complications, there were two instances of lighting-up of old infection in the hip joint, two cerebral vascular accidents, nine dislocations of the prosthesis, and two cases of terminal pneumonia. In four patients, foot-drop developed which was transitory, and in one a fracture occurred during surgery. Secondary surgery was necessary ten times; in two patients the prosthesis failed.

The average age of the patients in whom complications developed was seventy-eight years.

Regarding the prevention of dislocation of the prosthesis from the acetabulum, the authors concluded that two measures should be stressed: pre-existing deformity, such as flexion contracture or adduction contracture, should be corrected, and the new joint should be protected by the prevention of deformity.

Rehabilitation of the Poliomyelitic Patient with Respiratory Involvement. Dr. Hart E. Van Riper of The National Foundation for Infantile Paralysis, New York, N. Y., presented an exhibit in which the goals in rehabilitation of the patient with respiratory paralysis were emphasized. These are:

1. Freedom, in so far as possible, from dependence on mechanical respiratory aids;

2. Ability to take care of personal needs, such as eating and dressing, and ambulation training when possible;

3. Social and economic independence according to individual interests and capacities.

Four cases were presented to illustrate how patients with varying degrees of disability can be helped to reach these goals. All patients had been discharged for at least a year at the time this exhibit was prepared.

Case 1. B. T., a fifteen-year-old farm boy, was admitted to the Poliomyelitis Respiratory Center at the University of Michigan in August 1951. He had rapidly progressing paralytic poliomyelitis with respiratory

failure. His vital capacity had dropped from 3,500 cubic centimeters to a point where it was unmeasurable. He was placed in a tank respirator. His acute and early postacute course was complicated by severe hypertension which cleared up spontaneously in about nine months. Both upper and lower extremities were severely involved.

Use of the cuirass respirator was begun in the second week of hospitalization, and soon he used the tank only at night, the cuirass and rocking bed being used during the day. He started unassisted breathing in the ninth week. By the ninth month, he was free from all mechanical respiratory aid except the rocking bed at night.

Fitted with dynamic opponens splints with wrist extensors on both hands and overhead slings, he received functional training in self-care. Typing, painting, and metal work helped to increase strength and coordination.

Because trying to walk was very important to him, he received limited ambulation training, although he could not use crutches.

The medical social worker worked out a school program to keep him up with his class, thus enabling him to return to his own age group when he was discharged.

He was discharged after fifteen months with a vital capacity of 900 cubic centimeters. His upper extremities were still weak, his right leg was completely paralyzed, and he was confined for the most part to a wheel chair. However, he used the rocking bed at night only; he discarded the hand splints and suspension slings except when typing; he could struggle across the room with the aid of a cane (even this limited ability gave him great satisfaction); he graduated from high school and will probably go to college.

Case 2. J. A., a housewife, twenty-six years old, was admitted to the Center in August 1951. She had some diaphragmatic weakness and some weakness in her left arm. She was put in the tank respirator. Her vital capacity had dropped to 250 cubic centimeters. Her upper intercostals were completely paralyzed and her lower intercostals were very weak. Both upper extremities had become almost completely paralyzed; her lower extremities were also involved.

The use of the cuirass, for very brief periods, was begun during the first week of illness. By the twelfth week, she was completely free from any mechanical breathing aid.

She received intensive physical therapy and functional training in the use of assistive equipment, without which she was virtually helpless. The muscles in the lower extremities, however, had improved greatly and ranged from good to normal.

When she could walk, a Taylor back brace was adapted with suspension slings in order to provide rigid support for her arms. Without this device she would have been confined to a wheel chair in order to use her arms and hands.

The medical social worker guided and encouraged her in planning realistically for her return home and resumption of her normal place as wife and mother.

She was discharged after seventeen months of hospitalization. Her right arm and shoulder were flail; her left shoulder was nearly flail; and the strength in her left arm varied from fair to poor. However, she no longer needed a splint on her left hand. She still could not dress, undress, bathe, or do any heavy housework. She could feed herself, use a telephone, wash dishes, run a vacuum cleaner, and do some gardening; she could help to care for her two little boys; and she could lead a normal social life.

Case 3. L. M., a male, thirty years of age, was admitted to the Center in August 1952 with respiratory failure and with an unmeasurable vital capacity. His vital capacity never rose above 120 cubic centimeters. He is a complete quadriplegic with poor neck muscles.

Part-time use of the cuirass was begun in the second week of illness, and, within a month, he was up in a wheel chair wearing the cuirass. By the fifth week, he could use the cuirass and the rocking bed; he was able to give up the tank respirator completely in the sixth week.

Functional training consisted in teaching him to use a mouth stick to turn the pages of a book and to type. Physical therapy was done to prevent contractures and to keep him limber.

Before his illness, he had had an excellent position with a public utilities company. He and the social worker explored job possibilities from the point of view as to what he could do with his superior technical knowledge despite his limited physical assets. He now works at home abstracting technical journals for the company for which he had formerly worked. He dictates to his wife who types the abstracts.

He was discharged after nine months of hospitalization. He still uses the cuirass and rocking bed at all times. He is still completely dependent on others for all of his needs. However, he does support his wife and two children.

Case 4. D. M., a male, thirty years of age, was admitted to the Center, having already been in a tank respirator for six months. He had a vital capacity of 900 cubic centimeters when supine and 1,500 cubic centimeters when sitting or standing. Both arms and shoulders were flail; both forearms and hands were weak. He had good trunk muscles and had practically normal lower extremities. On his second day at the Center,

he was out of the tank respirator twelve of the twenty-four hours. Within a week, he no longer used any mechanical respiratory aid.

He was fitted with an adapted Taylor back brace to give his arms rigid support. Functional training consisted in teaching him to care for his personal needs and to practise writing, using the telephone, opening file drawers, and handling folders—all of which abilities he needed in order to return to his work as assistant administrator in a hospital. His upper arms and shoulders were still flail; his forearms and the left hand had only fair muscle power; his right hand was good.

He returned to work a week after discharge from the hospital. He no longer used his back brace or hand splints. The only piece of adapted equipment he requires is a specially designed telephone.

Results of Hip Arthroplasty—Judet Acrylic and Vitallium Head Prostheses. Dr. Philip D. Wilson, Dr. Philip D. Wilson, Jr., and Dr. Paul Harvey. Hospital for Special Surgery, New York, N. Y.

Injuries about the Elbow. Dr. Chestley L. Yelton of the Lloyd Noland Hospital, Fairfield, Alabama, presented an exhibit of forty-eight films demonstrating the various injuries about the elbow and their proper treatment. Most of the injuries had been treated by closed reduction.

Injuries of the lateral condyle of the lower end of the humerus with displacement had been treated by open reduction. Examples of old untreated fractures of the lateral condyle were shown and the ultimate deformity and the delayed ulnar palsy were demonstrated.

It was suggested that only those fractures of the medial epicondyle of the humerus in which the epicondyle was incarcerated in the joint required open reduction. A fracture of the radial neck with the proximal radial epiphysis completely displaced was shown. This had been treated by open operation and the replacement of the radial head. An eight-year follow-up of the fracture was exhibited, and it was pointed out that the radial head should never be excised in a growing child.

Fixation of fractures of the olecranon by means of a single longitudinal screw was demonstrated. In extremely comminuted fractures of the olecranon with a stable joint, the treatment of choice is excision of the olecranon and repair of the triceps. Roentgenograms were shown demonstrating the necessity for some form of internal fixation in Monteggia fractures. In these fractures stability cannot be obtained by other means.

AUDIO-VISUAL PROGRAM

Saturday Afternoon, January 29, 1955

Grafting (Toe to Hand, to Substitute for Finger). Dr. A. V. Zimbrón, Mexico City, Mexico.

Rehabilitation in Poliomyelitis. Dr. William J. Schnute, Chicago, Illinois.

Vitallium Lower Humeral Replacement Prosthesis. Dr. C. S. Graybill, Lawton, Oklahoma.

Trapezius Transplant for Deltoid Paralysis. Dr. Homer H. Stryker, Kalamazoo, Michigan.

Poliomyelitis: Extrinsic Transfers about the Hand. Dr. C. E. Irwin, Warm Springs, Georgia.

Total Excision of Semilunar Cartilages. Dr. Duncan McKeever, Houston, Texas.

Repair of Massive Avulsion, Shoulder Rotator Cuff. Dr. Joseph H. Reno, Bethlehem, Pennsylvania.

Double Rush Nailing of Femur. Dr. Kenneth G. Jones, Little Rock, Arkansas.

Sling Procedure for the Correction of Splay-Foot, Primus Varus and Hallux Valgus Deformities. Dr. Robert J. Joplin, Boston, Massachusetts.

Sunday Afternoon, January 30, 1955

Flat-Foot Plasty. Dr. Nicholas J. Giannestras, Cincinnati, Ohio.

The Moore Self-Locking Vitallium Hip Prosthesis. Dr. Austin T. Moore, Columbia, South Carolina.

Experimental Causation of Congenital Defects in Developing Chickens. Dr. P. K. Duraiswami, New Delhi, India.

Monday Afternoon, January 31, 1955

The Opponens Spacer. Dr. Walter E. Landmesser, Jr., Newington, Connecticut.

Surgical Approaches to the Bones of the Foot. Veterans Administration Medical Department under the direction of Dr. LeRoy C. Abbott, San Francisco, California.

Wednesday Afternoon, February 2, 1955

Trigger-Finger in Children and Adults. Dr. John J. Fahey, Chicago, Illinois, and Capt. John A. Bollinger, Washington, D. C.

Abdominal Fascial Transplants. Dr. Charles L. Lowman, Los Angeles, California.

Amputations and Prostheses for Congenital Deformities. Dr. Harry D. Morris, New Orleans, Louisiana.

EXHIBIT OF GADGETS AND NEW IDEAS

A Sterilizable Container for a Complete Set of Intramedullary Femoral Nails. Dr. W. Compere Basom, Dr. Louis W. Breck, Dr. Morton H. Leonard, and Dr. Mario Palafox, El Paso, Texas.

Motorized Low-Speed Hip Reamer. Dr. Louis W. Breck, Dr. W. Compere Basom, and Dr. Morton H. Leonard, El Paso, Texas.

Traction Screw for Use in the Closed Reduction of Central Hip Dislocations and Fractures about the Acetabulum. Cmdr. Alvis B. Dickson, United States Naval Hospital, Philadelphia, Pennsylvania.

A New Hand Drill for Kirschner Wires for Hand Surgery. Dr. Kenneth G. Jones, Little Rock, Arkansas.

1. *Tendon Stripper (Retractable Hook Type);* 2. *Bone Perforator. Instruments Used to Facilitate Sling Procedure Operation for Correction of Splay-Foot.* Dr. Robert J. Joplin, Massachusetts General Hospital and Harvard Medical School, Boston, Massachusetts.

The Opponens Spacer. Dr. Walter E. Landmesser, Jr., and Dr. Maurice M. Pike, Newington Home and Hospital for Crippled Children, Newington, Connecticut.

Magnetic Cassette Holder for Lateral Positions (Doctor—Save Those Hands!). Dr. Jay L. Plymale, Marion General Hospital, Marion, Ohio.

Lateral Films of Hip in Surgery without Irradiating the Surgeons or Nurses. Dr. George T. F. Rahilly, Fort Lauderdale, Florida.

Case Survey Tabulator. Dr. Charles Rombold, Wichita, Kansas.

Instruments for Lateral-Position Disc Surgery. Dr. Robert M. Rose, Louisiana State University Medical School, New Orleans, Louisiana.

A Simple Appliance to Prevent Proximal Migration of an Intramedullary Kirschner Wire. Dr. Adolph Segal, Orinda, California.

Hog Ring to Prevent Displacement of Naden-Rieth Prosthesis. Dr. Paul Spray, Oak Ridge, Tennessee.

Sleeve for Medullary Nail. Dr. Dana M. Street, Veterans Administration, Medical Teaching Group Hospital, Memphis, Tennessee.

(1) *Multiple Medullary Wires in Fixation of Tibial Fractures;* (2) *Retrieving Bone Biopsy Trephine.* Dr. Joseph E. Wheeler, Veterans Administration Hospital, Alexandria, Louisiana.

A Method by Which the Old Hawley-Scanlan Fracture X-Ray and Orthopaedic Table May Be Given a Lateral Tilt to Facilitate Nailing Intertrochanteric Fractures That Reduce in External Rotation. Dr. Robert O. Whitson, Baytown, Texas.

Modified Kerrison Rongeur. Dr. Heins Wichman, Morristown, New Jersey.

(1) *One-Handed Non-Pinching Cast Spreader;* (2) *Acromioclavicular Separation and Clavicle-Fracture Splint.* Dr. J. Howard Varney, Bakersfield, California.

AMERICAN ACADEMY FOR CEREBRAL PALSY

As Prepared by Winthrop Phelps, M.D., Baltimore, Maryland

The Eighth Annual Meeting of the American Academy for Cerebral Palsy was held at Williamsburg, Virginia, November 4 to 6, 1954. The program follows:

Thursday Afternoon, November 4

The Cerebral Palsy Problem in 1954. Dr. Meyer A. Perlstein summarized the general progress in all lines in the treatment of cerebral palsy and the indications as to the future.

A Practical Routine for Discerning Oculomotor Defects in Cerebral Palsied Children. Dr. George P. Guibor dealt with certain simple tests that can be carried out by all doctors, not specialists, and demonstrated these tests.

An Approach to the Dental Treatment of Children with Cerebral Palsy. Dr. Roy L. Lindahl reviewed the methods of handling dental problems in cerebral palsied children at the North Carolina State Hospital for Cerebral Palsied Children. The paper was read by Dr. Lenox Baker.

Symposium: Devices Found Useful in the Treatment of Cerebral Palsy. Dr. Harry E. Barnett demonstrated various gadgets and useful pieces of apparatus, such as adaptive equipment for chairs and tables, self-feeding apparatus, and weighted cuffs, which have been used in various clinics.

Presentations were made by: Dr. William Berenberg, Dr. Randolph K. Byers, Dr. Peter Cohen, Dr. Lucile Eising, Dr. George A. Reich, Dr. Samuel B. Thompson, and Dr. Jessie Wright.

Friday, November 5

Speech and Hearing Evaluation of Cerebral Palsied Children. Dr. Harold Westlake presented his testing charts. These can be used by doctors taking care of these children, who are not specialists in the field of hearing.

Aphasia in Cerebral Palsy. Dr. Peter Cohen described what has been called aphasia giving his experience in a small series of patients.

Treatment of the Spastic Hemiplegic. Dr. George G. Deaver demonstrated the methods used in his clinics in the retraining of hemiplegic patients. The functional methods of bringing about coordinated use of the legs and arms were shown. He discussed the total evaluation of the characteristics of gait in hemiplegic patients.

Neonatal Dental Dysplasias in Cerebral Palsy. Dr. Naury Massler and Dr. Meyer A. Perlstein made a very detailed and careful analysis of the prenatal, natal, and postnatal changes in the teeth.

Sensory Disturbances in Hemiplegics. Dr. Bronson Crothers dealt with special tests to determine the sensory changes in the hemiplegic patient. The various tests were shown and explained in an excellent movie. Other sensory changes, such as limitations, were included.

Description of the Twelve Types of Athetoids. Dr. Winthrop M. Phelps described the twelve types of athetoid patients and the differential diagnosis of these types.

Studies in Experimental Cerebral Palsy: Bilateral Sensorimotor and Total Decortication. Dr. Ann Marie Travis and Dr. Clinton N. Woolsey had experimented with the gradual complete decortication and survival of monkeys. A study of the retained movements and activities of these totally decorticated animals was made.

Experiments in the Surgical Relief of Athetosis and Other Hyperkinesias Associated with Cerebral Palsy. Dr. Russell Meyers presented a new approach to the operative control of athetosis in which the region of the cerebrum peduncles has been varied by what might be called a "crusotomy". This is proving satisfactory so far and is an advance in the neurological surgical procedures.

MID-CENTRAL STATES ORTHOPAEDIC SOCIETY

As Reported by H. O. Anderson, M.D., *Secretary-Treasurer*, Wichita, Kansas

The Second Annual Meeting of the Mid-Central States Orthopaedic Society was held in St. Louis on April 15 and 16, 1955, under the presidency of Dr. Vilray P. Blair, Jr. The Scientific Program had been arranged by Dr. Oscar P. Hampton, Jr., and Dr. Robert O'Brien. The meeting was in every way successful; it was thoroughly enjoyed by 115 members and guests.

Friday Morning, April 15, 1955

Dr. Vilray P. Blair, Jr., Presiding

Dr. Robert Shanewise discussed the Relationship of Thyroid Activity in Legg-Perthes Disease; Dr. C. H. Crego and Dr. Marshall Conrad presented Results of Treatment of Congenital Dislocation of the Hip; Dr. George Scheer reported on Paralytic Scoliosis and Scoliosis following Laminectomy. After a short intermission, the following four reports were presented: Obturator-Sciatic Neurectomy for Painful Hip by Dr. Leon Fox; Radical Sympathectomy in Sympathetic Dystrophies by Dr. K. D. Coldwater; Giant-Cell Tumors by Dr. Lauren V. Ackerman and Dr. William Murphy; and Cardiac Arrest by Dr. Rollin Hanlon, Professor of Surgery, St. Louis University School of Medicine.

Friday Afternoon, April 15, 1955

Dr. Oscar P. Hampton, Jr., Presiding

Dr. Carl Moyer, Professor of Surgery, Washington University School of Medicine, discussed Fluid and Electrolyte Balance in Trauma in the Aged. Following Dr. Moyer's discussion, a Symposium was held on Intramedullary Nailing of Fractures of the Tibial Shaft, with Dr. Oscar P. Hampton, Jr., as Moderator. Included in the Symposium were the following: Techniques of Intramedullary Nailing of the Tibia and Postoperative Care by Dr. J. Otto Lottes; Applicability to Fresh Fractures and Non-Unions by Dr. Robert Funsch; Complications by Dr. Richard T. Odell; and Results as Compared with Other Methods by Dr. Lloyd J. Hill. A thoroughgoing discussion and many questions and answers followed. Following the Symposium, there was a short intermission, after which the Executive Session was held.

In the evening, a dinner was given at the University Club.

Saturday Morning, April 16, 1955

Dr. Robert O'Brien, Chairman

The following papers were presented: Evaluation of Cerebral Palsy Treatment by Dr. D. Elliott O'Reilly; The So-Called Chondromalacia Patellae by Dr. William Bauer; Patellectomy in Fractures and Hypertrophic Arthritis by Dr. Roland Neumann and Dr. Garland Smith; and Reconstruction of the Patellar Ligament with a Dermal Graft by Dr. Vilray P. Blair, Jr.

After a short intermission, a Symposium was held on Hip Prostheses with Dr. Robert O'Brien as the Moderator. The following aspects were discussed: Surgical Approaches, Technique, Choice of Prosthesis, and Postoperative Care by Dr. I. B. Horwitz and Dr. M. I. Lenobel, and Prosthetic Arthroplasty of Hip in a Young Rheumatoid Arthritic by Dr. Earl P. Holt, Jr. A discussion of complications followed, after which a number of cases were presented.

The following officers were elected to serve during the year 1955 to 1956:

President: Dr. Elias Margo, Oklahoma City, Oklahoma;
Vice-President: Dr. J. Sims Norman, Pueblo, Colorado;
Secretary-Treasurer: Dr. H. O. Anderson, Wichita, Kansas.

Board of Directors:

Dr. Vilray Blair, Jr., St. Louis, Missouri;
Dr. Joseph Gross, Omaha, Nebraska;
Dr. Richard Logue, Little Rock, Arkansas.

The Third Annual Meeting will be held in Oklahoma City on April 20 and 21, 1956.

NORTH CAROLINA ORTHOPEDIC ASSOCIATION

As Reported by George W. Holmes, M.D., *Secretary*, Winston-Salem, North Carolina

The Ninth Annual Meeting of the North Carolina Orthopedic Association was held on October 2 and 3, 1954, at the Bowman Gray School of Medicine, Wake Forest College, Winston-Salem, North Carolina, under the presidency of Dr. Julian E. Jacobs of Charlotte. The Scientific Program had been arranged by Dr. Frank Forsyth and Dr. Cabell Young, Jr. Dr. T. Campbell Thompson, President of The American Academy of Orthopaedic Surgeons, was the guest of honor. Other official guests of the Association were Dr. C. B. Kendall and Colonel C. H. Warren of Raleigh. Four honorary members and four guests from the South Carolina Orthopedic Association and the Georgia Orthopedic Association attended. During the morning of October 2, Dr. Eben Alexander of the Department of Neurosurgery spoke on Metastatic Lesions of the Spine. Dr. Ira H. Rapp, Charlotte, discussed Quadricepsplasty; The Antiphlogistic Steroids were discussed by Dr. Ernest Young of the Department of Medicine; Treatment of Myelomeningocele was discussed by Dr. Courtland Davis of the Department of Neurosurgery and by Dr. Cabell Young, Jr., of the Department of Orthopaedic Surgery. Dr. Frank Stelling of Greenville, South Carolina, presented a paper entitled Results in the Treatment of Scoliosis.

The afternoon session was opened by Dr. T. Campbell Thompson who spoke on the Management of Orthopaedic Conditions of the Fore Part of the Foot. A very stimulating and altogether worth-while discussion followed Dr. Campbell's presentation.

Much of the remainder of the afternoon was taken up with reports of interesting cases by members and guests of the Association.

Dr. Robert A. Moore of Winston-Salem was presented by Colonel C. H. Warren, Director of Vocational Rehabilitation for the State of North Carolina, with a "citation for outstanding service in the field of vocational rehabilitation for the year of 1954".

Twenty-five interesting bone conditions were exhibited by gross and microscopic sections in view boxes, together with abstracts of the clinical history and physical findings. The members and guests recorded their diagnoses on appropriate blanks; and, after all of these had been filed, it was found that Dr. George H. Lane of Greenville, South Carolina, had the highest score of correct diagnoses.

The Annual Dinner was held in the evening.

The following officers were elected for the ensuing year:

President: Dr. George W. Holmes, Winston-Salem;
Vice-President: Dr. Stanley Atkins, Asheville;
Treasurer: Dr. Walter Hunt, Raleigh.

New members elected to the Association are:

Dr. Earl W. Schafer, High Point;
Dr. Christian Siewers, Fayetteville;
Dr. Alfred Berkely, Charlotte;
Dr. J. Leonard Goldner, Durham;
Dr. Wayne Lee, Charlotte;
Dr. John A. Powers, Charlotte.

October 3 was devoted to social activities.

TENNESSEE STATE ORTHOPAEDIC SOCIETY

As Reported by R. Beverly Ray, M.D., *Secretary*, Memphis, Tennessee

The Seventh Annual Meeting of the Tennessee State Orthopaedic Society was held on March 13, 1955, under the presidency of Dr. Marcus J. Stewart, at the Institute of Pathology, University of Tennessee School of Medicine, Memphis, Tennessee. During the morning Scientific Session the following papers were presented:

Cysts of the Semilunar Cartilage by Dr. A. H. Crenshaw;

The Use of the Charnley Clamp in Compression Arthrodeses in the Lower Extremities by Dr. Lee W. Milford;

Post-Traumatic Dystrophy—Report of Three Cases by Dr. William T. Howard;

Local Resection in Malignant Lesions—With Case Reports by Dr. R. Beverly Ray;

Prosthesis to Replace One Surface of the Knee Joint by Dr. Dana M. Street;

Treatment of Bone and Joint Tuberculosis by Surgical Drainage and Streptomycin by Dr. George B. Higley;

Bone-Grafting for Perthes' Disease by Dr. Alvin J. Ingram.

Dr. Claude N. Lambert, Associate Professor of Orthopaedic Surgery, University of Illinois School of Medicine, was the guest speaker; his address was the highlight of the meeting. It consisted of a thorough presentation of Upper-Extremity Prostheses in Juvenile Amputees, illustrated with lantern slides and a colored motion picture. A number of prostheses were demonstrated and their application and special functions were shown.

After lunch, which was held at the Baptist Memorial Hospital, the afternoon Scientific Session consisted of the following reports:

Errors in Intramedullary Nailing of the Femur by Dr. Hugh Smith;

Joint Resection by Dr. W. L. Whittemore;

Kirschner-Wire Fixation of Colles' Fracture by Dr. R. A. Calandruccio (by invitation).

At the close of the Scientific Session, a short business meeting was held at which the following officers were elected for the ensuing year:

President: Dr. John J. Killeffer, Chattanooga;

Vice-President: Dr. W. Houston Price, Chattanooga;

Secretary: Dr. Paul C. Thompson, Chattanooga.

The 1956 meeting will be held in Chattanooga during the month of March.

TRI-STATE ORTHOPEDIC SOCIETY

A meeting of the Tri-State Orthopedic Society was held at Hot Springs, Virginia, April 29 and 30, 1955. The program was as follows:

Friday, April 29, 1955

Study of Ligaments of Normal Ankles by Dr. H. M. Hills, Jr., Charleston, West Virginia;

Bone Changes in Leukaemia by Dr. V. L. Peterson, Charleston, West Virginia;

Patellectomy (colored motion picture) by Dr. George Miyakawa, Charleston, West Virginia;

A Plea for Conservative Use of a Radical Procedure by Dr. A. L. Bershon, Toledo, Ohio.

Saturday, April 30, 1955

Chondrodystrophies and Chondrodysplasias by Dr. J. A. Heckman, Huntington, West Virginia;

Congenital Dysplasia of the Hip by Dr. R. L. Anderson, Charleston, West Virginia;

Pathology of Knee Menisci by Dr. Walter Putschar, Charleston, West Virginia;

Use of Cutis in Arthroplasty of the Knee by Dr. J. E. Brown and Dr. Darrell T. Shaw, Cleveland, Ohio;

Plastic Repair of Posterior Defects of Knee-Joint Capsule in Children by Dr. F. A. Scott, Huntington, West Virginia;

Discussion of interesting cases;

Clinical histories.

FRANK HASTINGS HAMILTON MEWBURN
1888–1954

It is with deep regret that we note the death on September 4, 1954, of Frank Hastings Hamilton Mewburn, O.B.E., B.A., M.D., C.M., F.A.C.S., F.R.C.S., Charter Member of The Canadian Orthopaedic Association, Fellow of The American Academy of Orthopaedic Surgeons, the first Chief of the Department of Orthopaedic Surgery of the University of Alberta, and founder of the Alberta Orthopaedic Society.

Dr. Mewburn was born in Lethbridge, Alberta, Canada, in 1888. He obtained his primary education at Upper Canada College and his Arts and Medicine degrees from McGill University. He was graduated from medical school in 1914.

Dr. Mewburn was always keenly interested in the Army, and during his medical course, he was an officer in the 20th Field Battery. On the outbreak of World War I, he went overseas with this unit as a combatant officer. In 1917, due to the shortage of medical officers, he was transferred much to his personal regret to the Medical Corps and served on the Surgical Service of the General Hospital at Taplow. He remained in this position until the end of hostilities. Upon his return to Edmonton, he was asked to serve as a Medical Officer with the Soldier's Civil Re-establishment, an office which he held for thirty years.

Because he had always been interested in orthopaedic surgery, he left his practice and went to Harvard Medical School and the Massachusetts General Hospital for postgraduate training. In 1923, Dr. Mewburn returned to private practice and became Chief of the Orthopaedic Department of the University of Alberta, establishing the first orthopaedic service west of Winnipeg. With his inspiration and example, this Department trained orthopaedic surgeons, who are now practising in Canada and the United States.

The most outstanding characteristics of Dr. Mewburn were his intellectual honesty and his apparent gruffness. This gruffness never fooled any child. He is best remembered by his students and confreres for his outstanding forthrightness and intellectual honesty. He retained a keen interest in the early history of the West until his death. He was an outstanding soldier, an understanding teacher, and a completely honest surgeon. His death after a prolonged illness will be mourned by all who knew him. He is survived by his wife and one son, Dr. Robert H Mewburn, of Vancouver.

R. Graham Huckell

LEMUEL D. SMITH
1883–1954

Lemuel D. Smith died on October 9, 1954, as a result of a coronary occlusion. Dr. Smith was an exceedingly active man all his life.

He was graduated from the Massachusetts Institute of Technology. While in school, he was very active in track, where he was among the first men to break the record of ten seconds for the 100-yard dash. He also rowed in the crew. Apparently he tired of the life of an engineer, for at the beginning of World War I, he entered Marquette University School of Medicine and was graduated in 1921. He served his residency under the guidance of Dr. Robert Osgood in Boston and, after he had finished his residency, he began his practice in Milwaukee. He was an instructor at Marquette University and, later, Assistant Professor. He was very popular with the students.

He was a member of the Central States Orthopaedic Club, the American College of Surgeons, the International College of Surgeons, and The American Academy of Orthopaedic Surgeons. He was very much interested in the history of the United States and made frequent visits to all parts of the country that were of any historical interest. Up to the summer of his death, he was active in sports and athletics.

He continued to practice medicine until a few days before his death.

Herman C. Schumm

ARTHUR EDGAR BENCE
1889–1954

Dr. Arthur Edgar Bence, orthopaedic surgeon of Wichita, Kansas, since 1926, died unexpectedly Friday afternoon, November 19, 1954.

Dr. Bence was born September 2, 1889, in Logan, Iowa, the son of Charles Franklin Bence and Emma May Lanpher Bence.

He was graduated from the University of Iowa in 1919 and received his medical degree in 1921. Following graduation, he did five years of postgraduate work at the University, part of it under Dr. Arthur Steindler in orthopaedic surgery. He had practised in Wichita since 1926 when he completed his University work.

Dr. Bence was a member of the American Medical Association, the Sedgwick County Medical Society, and The American Academy of Orthopaedic Surgeons.

H. O. Anderson

JOHN T. HODGEN
1884–1954

John T. Hodgen, M.D., died October 9, 1954. He had been suffering from a mild heart ailment for a number of weeks, but his sudden death was a shock to his friends and associates.

John Hodgen was born in Rye Beach, New Hampshire, on July 31, 1884, the son of Harry and Agnes Hart Hodgen and grandson of John T. Hodgen, M.D., of St. Louis, Missouri. He received his A.B. degree from the University of Michigan in 1906 and his Doctor of Medicine degree in 1910. His postgraduate work consisted of four years of orthopaedic training at the Boston Children's Hospital with Dr. Robert Lovett, just prior to World War I.

Following this training, he was assigned to the Rockefeller Foundation and was in charge of the Field Clinics of the State of New York during the severe poliomyelitis epidemic of 1916. During World War I, Dr. Hodgen served with Unit Q, Red Cross Hospital, as Chief of the Orthopaedic Section, and attained the rank of Major. Immediately following World War I, Dr. Hodgen returned to the United States and spent one year in New York City with Dr. Sayre and Dr. Hibbs. In 1920 he returned to Grand Rapids and opened the first full-time, well staffed Children's Orthopaedic Clinic. He was a guiding influence in developing the Mary Free Bed Guild Children's Hospital and Orthopaedic Center which began as a twelve-bed unit in 1931. He was Chief of Staff for many years.

Dr. Hodgen was a vigorous clinician and somewhat of a traditionalist. He taught by example and free discussion. Scrupulously honest intellectually, he was exacting of the younger men but at the same time very tolerant. Dr. Hodgen did very little writing, his energies being consumed in clinics and the convalescent care of the crippled children. He possessed an unusual insight into the mental problems besetting the handicapped.

He was a member of the American Medical Association, a Fellow of the American College of Surgeons, a member of the Clinical Orthopaedic Society, the Michigan State Medical Society, Kent County Medical Society, The American Academy of Orthopaedic Surgeons, and a diplomate of The American Board of Orthopaedic Surgery. He was Extramural Lecturer in Postgraduate Medicine of the University of Michigan in 1934 and 1935 and in 1937 and 1938.

Dr. Hodgen will long be remembered as the pioneer orthopaedic surgeon of western Michigan. His loss will be deeply felt by his colleagues for many years to come.

Charles H. Frantz

CORRECTION

Dr. Wickstrom, Dr. Haslam, and Dr. Hutchinson have requested that correction be made of an error in their article "The Surgical Management of Residual Deformities of the Shoulder Following Birth Injuries of the Brachial Plexus" as it appeared in the January 1955 issue of *The Journal*.

On page 34, paragraph 2, the sentence beginning on line two should be changed to: "Open reduction of the dislocation, with release of the subscapularis, as described by Fairbank, was performed, but the operation was modified by completely releasing the pectoralis major instead of nicking or notching the upper margin of this tendon (done to facilitate the localization of the long head of the biceps before dividing completely the subscapularis tendon) and by transfixing the humeral head . . . after operation (Fig. 7)". The legend for Figure 7, page 33, should read: "Schematic drawing of modification of Fairbank's open reduction . . . after four weeks".

News Notes

The Sixty-eighth Annual Meeting of **The American Orthopaedic Association** will be held at The Greenbrier, White Sulphur Springs, West Virginia, June 19 to 22, 1955. The preliminary program appeared in the April issue of *The Journal*, pages 430 and 431.

The next Annual Meeting of the **Western Orthopedic Association** will be held in Honolulu, Hawaii, in November 1955 under the presidency of Dr. J. Warren White.

The Eleventh Annual Meeting of the **American Society for Surgery of the Hand** will be held at the Palmer House, Chicago, Illinois, on Friday, January 27, 1956.

The Second Annual Meeting of the **Orthopaedic Research Society** will be held at the Palmer House, Chicago, Illinois, January 28, 1956.

The next Annual Meeting of **The American Academy of Orthopaedic Surgeons** will be held at the Palmer House, Chicago, Illinois, January 28 to February 2, 1956.

The Eighty-third Annual Meeting of the **American Public Health Association** and forty related organizations will be held at the Municipal Auditorium, Kansas City, Missouri, from November 14 to 18, 1955.

Reprints of an article entitled "Observations on Failures of Back Checks on Artificial Legs" by Francis L. Smith and John L. Young, Ph.D., may be obtained by writing to: Mellon Institute, 4400 Fifth Avenue, Pittsburgh 13, Pennsylvania.

The Annual Meeting of the **American Academy for Cerebral Palsy** will be held under the presidency of Dr. Lenox D. Baker in Memphis, Tennessee, October 10, 11, and 12, 1955. The meetings are open to members of the medical profession and allied professions who are interested in cerebral palsy. The three-day program will include instructional courses in the various phases of cerebral palsy and its treatment, as well as a formal scientific program. Those who wish to attend may obtain an invitation from Dr. Robert A. Knight, 869 Madison Avenue, Memphis 3, Tennessee. Hotel reservations are to be made directly with Mr. Scott Stewart, Manager of the Claridge Hotel, Memphis, Tennessee, which is convention headquarters.

The American Board of Orthopaedic Surgery has announced that the final date for filing application for the Part II examination to be given in January 1956 is August 15, 1955. Application should be made to Dr. Harold A. Sofield, Secretary, 116 S. Michigan Avenue, Chicago 3, Illinois.

A specialized placement service for compensation claimants has been added to the rehabilitation activities for the industrially injured at the **Institute for the Crippled and Disabled,** 400 First Avenue, New York City. The new service provides carriers and claimants with specialized job placement either as part of a comprehensive rehabilitation program or as a separate service.

KAPPA DELTA AWARD

A prize of $1,000.00 donated by the **Kappa Delta Sorority,** is offered annually by The American Academy of Orthopaedic Surgeons for the best research related to orthopaedic surgery, and performed by an American citizen in the United States.

Selection for the current year will be made from publications after January 1, 1953, or research presented to the Committee on Scientific Investigation of The American Academy of Orthopaedic Surgeons before November 1, 1955.

Researchers interested in competing may secure information from the Chairman of the Committee on Scientific Investigation of The American Academy of Orthopaedic Surgeons, Dr. Paul R. Lipscomb, 200 First Street, S.W., Rochester, Minnesota.

MOTION PICTURE FILMS

A completely revised Fourth Edition of "Professional Films" is now in compilation. It will include new sections providing biographical data on authors and information on the audiovisual activities of medical schools, dental schools, and postgraduate teaching centers.

Over 28,000 copies of previous editions are in use by medical and dental schools, program chairmen of state and specialty societies, and others here and abroad. The Academy-International of Medicine provides this valuable audiovisual information to the profession at large, without profit, as one of its contributions toward elevating the standards of medical and dental services by expediting the disseminating of professional knowledge.

Any film author should write for information to: Academy-International of Medicine, 601 Louisiana Street, Lawrence, Kansas.

LETTER TO THE EDITOR

Priority in Recognizing the Diaphragm as the Cause of Funnel-Chest Deformity

To the Editor:

In a paper entitled "Pigeon Breast, Funnel Chest, and Other Congenital Deformities of the Anterior Chest Wall",[d] read before the Orthopedic Section of the American Medical Association in June 1954, the following statement was made: "Brown . . . called attention to the fact that the xiphoid is retracted during inspiration and established the fact that a short central tendon of the diaphragm is responsible for this." Exception was taken to thus giving credit to Brown and my attention was called to a paper by Ludwig Meyer [a].

In this article Meyer described the first operation undertaken for the correction of funnel chest by Freund's method (a procedure which was never generally adopted) and referred to a paper by Woillez [b]. Woillez described in great detail a case of funnel chest in a medical student, twenty-two years old. At the end of the paper he declared that this could not be congenital because he had never encountered a similar case in the examination of more than 1,000 newborn infants. He believed that the deformity must be caused by the pull of the diaphragm and postulated that the central tendon of the diaphragm had contracted because of a pathological condition analogous to the contracture of the palmar fascia in Dupuytren's contracture. Obviously, he could not prove this because surgery had not advanced to the point where he could actually observe the diaphragm in action or note its condition.

Meyer also quotes, among others, Max Versé [c]. Versé performed an autopsy on a woman, forty-eight years old, who had died of pulmonary tuberculosis and who had a funnel chest. This was a most elaborate postmortem examination, which consisted in first fixing the chest and upper portion of the abdomen. Two days later longitudinal sections were made through the thorax and a vast number of measurements were made which were subsequently compared with similar measurements in 205 normal subjects. In the autopsy protocol Versé noted the abnormalities of the diaphragm but completely missed the importance of these observations, even arguing that Woillez' theory was untenable. This is understandable because he was doing an autopsy and not observing a breathing individual.

Ochsner and DeBakey [f], in describing a case of their own, made a most extensive review of the literature — listing 142 references — and gave a brief description of all the surgical procedures used to that time. They referred to Woillez and also to Ebstein, who quoted an observation similar to that of Woillez made by Bauhinus [a] in 1596.

A. Lincoln Brown [b] had several cases of his own and made the independent observation that the deformity was caused by an abnormal pull of the diaphragm which he noted, at operation, to be the result of a short central tendon. In searching the literature he came upon the case of Bauhinus and was so impressed by it that he quoted it in the original Latin. What is of greater importance, Brown fitted his surgical procedure to this etiology and thus established the surgical principles which made it possible for the rest of us to correct this deformity successfully.

Thus, with all respect to Woillez, his theory was antedated 260 years by Bauhinus and proved seventy-nine years later by Brown. But there is glory enough for them all.

Charles W. Lester, M.D.
70 East 80th Street
New York 21, N. Y.

May 4, 1955

a. Bauhinus, Ioannes: Sterni cum costis ad interna reflexio natiua, spirandi difficultatis caussa. *In* Observationum Rararum, Novarum, Admirabilium, et Monstrosarum. Ioannes Schenck a Grafenberg. Tomus I, Librum II (Observatio 264), 507–508. Frankfurt, 1600.

b. Brown, A. L.: Pectus Excavatum (Funnel Chest). Anatomic Basis; Surgical Treatment of the Incipient Stage in Infancy; and Correction of the Deformity in the Fully Developed Stage. J. Thoracic Surg., **9:** 164–184, 1939.

c. Ebstein, Erich: Die Trichterbrust in ihren Beziehungen zur Konstitution. Mit Bemerkungen zu ihrer Ätiologie, Familiarität, Klinik sowie Behandlung. Zeitschr. f. Konstitutionslehre, **8:** 103–116, 1921.

d. Lester, C. W.: Pigeon Breast, Funnel Chest, and Other Congenital Deformities of the Chest. J. Am. Med. Assn., **156:** 1063–1067, 1954.

e. Meyer, Ludwig: Zur chirurgischen Behandlung der angeborenen Trichterbrust. Berliner Klin. Wochenschr., **48:** 1563–1566, 1911.

f. Ochsner, Alton, and DeBakey, Michael: Chōnē-Chondrosternon. Report of a Case and Review of the Literature. J. Thoracic Surg., **8:** 469–511, 1939.

g. Versé, Max: Über die kongenitale Trichterbrust mit besonderer Berücksichtigung der normal-anatomischen Verhältnisse. Beitr. z. Path. Anat. u. z. Allg. Path., **48:** 311–342, 1910.

h. Woillez: Sur un cas de difformité thoracique considérable, avec déplacement inoffensif de plusieur organes, et signes stéthoscopiques particuliers. L'Union Méd., **6:** 515–521, 1860.

CORRECTION

Several errors appeared in the summary of the paper by Dr. Charles W. Lester, *Pigeon Breast, Funnel-Chest, and Other Congenital Deformities of the Anterior Chest Wall*, presented at the June 1954 meeting of the American Medical Association, Section on Orthopedic Surgery. This summary was published in the Proceedings Section of the December 1954 issue of *The Journal*.

On page 1293 the meaning may be clarified if the sentence beginning on the next to the last line, last paragraph, is changed to read "If the growth of the pairs of ribs which attach to the mid-portion of the sternum exceeds that of the other ribs, there may occur buckling at the costochondral junctions of the ribs growing proportionately more rapidly and the central part of the sternum may be pushed forward 'in an arc'".

To the sentence beginning on the last line of page 1293 and ending on the first line of the next page add "; the resulting protrusion will be oblique".

On page 1294, the meaning in the sentence beginning on the first line may be better expressed if the sentence is changed to read "If disproportionate growth occurs in the ribs on one side while the ribs on the opposite side grow normally, the latter may fix the sternum and the buckling of the overgrowing ribs may cause protrusion of costochondral junctions either at the sternum or in the costal arch of the same side".

The next sentence will better convey the author's meaning if the subject is changed from "Patients with the oblique type of deformity" to "Patients having protrusion deformities".

On page 1294, paragraph 3, line 3, to the sentence ending on this line add: ", leaving the posterior cortex of the sternum intact".

On page 1294, paragraph 3, the sentence beginning on line 3 should be changed to read: "The xiphoid is detached from the sternum and removed; the beds of the resected sixth and seventh costal cartilages with the intervening interchondral ligaments are cut from their attachment to the sternum, and the substernal ligament [a] is divided."

On page 1294, paragraph 3, next to the last line, the author's name is Dailey.

On page 1294, paragraph 5, line 1, the phrase, "as originally described by Brown," should have been omitted. In the same paragraph, line 2, the word "second" should have been written "seventh".

a. Brown, A. L.: Pectus Excavatum (Funnel Chest). Anatomic Basis; Surgical Treatment of the Incipient Stage in Infancy; and Correction of the Deformity in the Fully Developed Stage. J. Thoracic Surg., **9:** 164–184, 1939.

Book Reviews

Die Erkrankungen der Wirbelsäule. Prof. Dr. Kurt Lindemann und Dr. Hans Kuhlendahl. Stuttgart, Ferdinand Enke Verlag, 1953. DM 46.

The task of summarizing our modern concepts of spinal lesions has been undertaken jointly by an orthopaedic surgeon, Kurt Lindemann, formerly of Hannover and now of Heidelberg, and a neurosurgeon, Hans Kuhlendahl of Düsseldorf. Their combined efforts have served to produce a timely reference work which relates the diseases of the spine to the anatomical and physiological changes in the nervous system. They make it clear that they are offering neither a detailed nor a final presentation of the subject. They are anxious to go beyond the borders of each specialty and to demonstrate the "symbiosis" between the spinal column and the nervous system. They have accomplished their mission well. They have not only advanced the knowledge of scientific principles but, in a practical way, have helped the patients suffering from back pain.

The opening chapter on morphology and general pathological physiology is well presented jointly by the two authors with skeletal drawings and photographs, as well as diagrams, which prepare the way for the chapters on movement and posture. The conventional chapter on congenital malformations is followed by one on acquired deformities. Scheuermann's disease is of especial interest to Prof. Lindemann.

The discussion of scoliosis reflects the historical European attitude. Rickets is not a significant cause in the United States but is still listed prominently as an etiological factor in Germany. Recklinghausen's neurofibromatosis is mentioned as a cause, but its tragic consequences are not emphasized and prompt fusion is not urged. Conservative treatment is discussed in detail. For the most part, exercises are still viewed with more favor than they are in the United States, although Prof. Lindemann is frank to state that all conservative treatment fails at times. He brands passive extension with frames and slings as fruitless in his experience and favors active gymnastics. He speaks of partially correcting an occasional case of scoliosis with a Risser jacket and of carrying out a Hibbs fusion with meticulous arthrodesis of the facets. He does the operation only between the fourteenth and seventeenth years. Early fusion of a progressive curve and prophylactic fusion of a severe paralytic curve are discussed.

For the presentation of intervertebral-disc pathology, the authors draw extensively on the recent literature and contribute studies of their own. The critical statistical reviews by Dr. Kuhlendahl are timely.

Of great value is the correlation of the spinal pathology with nerve involvement. Excellent diagrams make clear the varied relationships in the cervical, thoracic, and lumbar regions. The neurosurgical procedures of Dr. Kuhlendahl merit careful study.

For completeness there are chapters on spondylolisthesis and inflammatory and neoplastic involvement of the vertebrae. Traumatic lesions are discussed from a therapeutic standpoint with industrial implications.

It is unfortunate that a book as well written as this will be available to so few in this country. It should be in all well equipped libraries as a reference work for the medical student, the general physician, and the surgeon of trauma. The orthopaedist and the neurosurgeon will find timely and simplified explanations of some of the back problems which they must clarify for lay and medical audiences.

Walter P. Blount, M.D.

Comroe's Arthritis and Allied Conditions. Joseph Lee Hollander, M.D., Editor. Philadelphia, Lea and and Febiger, 1953. $16.00.

The Fifth Edition of this widely used textbook retains the same format as the previous edition and contains fifteen more text pages and ninety-three new illustrations. However, it has been revised extensively and many sections have been rewritten. The chapters concerning the etiology of rheumatoid arthritis, focal infection, the endocrine glands, the effect of pregnancy and jaundice on arthritis, diet and vitamins, non-articular rheumatism (fibrositis), Dupuytren's contracture, low-back pain and sciatica, and the collagen diseases have been brought up to date, while new chapters have been added concerning corticotropin, cortisone, and hydrocortisone, as well as one dealing with the intra-articular injection of hydrocortisone. The extensive bibliographies at the end of each chapter have been brought up-to-date.

For a textbook concerned with a field in which such rapid advances are being made, this is surprisingly up-to-date. The Editor and his collaborators have done an outstanding job in this respect. The book is well written and well illustrated.

It is somewhat surprising to find that, in spite of the presence of four orthopaedic surgeons among the contributing editors, some sections, such as the ones concerning internal derangement of the knee and the painful shoulder, have been written by physicians. These subjects would seem to fall within the province of the orthopaedist.

For the most part this reviewer found the book excellent and most worth-while reading. A few points

were noted with which one might take issue. For example, many would not agree that the sacro-iliac joints are among those most commonly sprained, as suggested in the chapter on traumatic arthritis and allied conditions. Similarly few would treat partial ruptures of the supraspinatus tendon with an abduction splint for five to six weeks, as suggested in the chapter on the painful shoulder. In the section on internal derangements of the knee joint one finds no mention of quadriceps exercises or of progressive-resistance exercises, as described by DeLorme. Similarly, primary repair of severe ligamentous injuries, as championed by O'Donoghue, is not discussed.

On the whole this book can be recommended highly as an excellent reference and source book for all those concerned with the treatment of joint diseases.

Thornton Brown, M.D.

GRUNDRISS DER ORTHOPÄDISCHEN KRANKENUNTERSUCHUNG. Priv.-Doz. Dr. G. Chapchal. Stuttgart, Ferdinand Enke Verlag, 1954. DM 25.50.

As the author indicates, this small volume is intended primarily for students and young physicians interested in orthopaedic diagnosis. It makes no attempt at presenting typical symptom complexes or establishing a basis for differential diagnosis in orthopaedics. In rigid adherence to this objective, the various parts of the body, the neck, the upper extremities, the trunk, and the lower extremities (including the hips, knees, and feet) are submitted to a description of the facts which can be elicited by inspection (at rest or in motion), palpation (at rest or in motion), functional ranges of motion (active and passive), mensuration, and joint puncture. Short descriptions of the techniques and illustrations of the characteristic x-ray appearance of a number of different conditions are given.

With but few exceptions, the author has happily avoided eponymous designations of the various signs and tests which are employed in the course of a routine orthopaedic examination. In the few instances where proper names are used such as Bryant's triangle, Hueter's or Schoemaker's line, Duchenne-Trendelenburg's phenomenon, or Thomas's method, the principles are described, but direct reference to the original source is unfortunately omitted. For the younger student who can read the uncomplicated German, the work should prove extremely useful as a guide in the avoidance of "errors of omission". It is particularly valuable in establishing arithmetical norms for the range of motion of the various joints of the body. The older student might perhaps be justified in objecting to categorical statements with regard to certain tests and measurements which, even though in consonance with the teaching of the Munich School, have elsewhere been subjected to criticism and correction.

Henry Milch, M.D.

DISEASES OF THE KNEE. Management in Medicine and Surgery. Anthony F. DePalma, M.D. Philadelphia, J. B. Lippincott Company, 1954. $20.00.

In approaching a work of this magnitude (800 pages, 450 illustrations), it is obviously impossible to review adequately the material presented. *Diseases of the Knee* is not designed as a book which one would sit down to read through in the course of a few evenings, but rather it is one to be used as a reference in regard to specific conditions about the knee or one to browse through at random in order to inform oneself or to refresh oneself concerning certain particular aspects of diseases of the knee.

In this book can be found information on almost anything a physician might wish to know in regard to the knee joint. There is, for instance, a very interesting chapter on the evolution of the knee joint, which seeks to explain the anatomy of the knee from a developmental standpoint. It may well be compared with the following chapter on comparative anatomy, since the various evolutionary stages of the knee joint are demonstrated and compared with the joint in present-day mammals. So too, the chapter on anatomy will be found to be extremely interesting and instructive, since it takes up not only the anatomy of the knee but also the relationship of the joint to the other joints in the lower extremity.

The author may appear at times to be somewhat didactic about controversial matters. This is indeed the prerogative of one who has spent as much time in collecting material as has this teacher. The student may, indeed, find himself lost in the wealth of material and discussion in regard to many of the conditions about the knee; for example, eighty pages are allotted to traumatic lesions of the menisci. Obviously, in such a complete dissertation, one may find some reference to almost any condition he is likely to encounter.

The section on fractures of the distal end of the femur and the upper end of the tibia seems to be out of place in a work which should be confined to intra-articular lesions. However, the material presented is interesting and not overlong. There is a brief section on wounds of the knee, which could well have been enlarged in order to include more specific information, such as that concerning the management of open wounds, particularly of infected gunshot wounds. There are 100 pages given to text and pictures concerning surgical procedures about the knee, in which the illustrations are unusually clear and the descriptions are good. The short section on amputations about the knee, covering only fifteen pages, is, of course, totally inadequate and is not matter to be properly included in a discussion of surgical procedures of the knee joint. This is, to some

extent, also true of the section on bone neoplasms, since it is obviously impossible to give extensive detail in regard to such tumors and since such tumors are in no way peculiar to the knee.

I think that the most important sections of the book are those which deal especially with specific conditions about the knee. These sections are all excellent and are well documented; the bibliography is, indeed, formidable. The student, the practising physician, and the orthopaedist will find material here to satisfy his every need.

Having some especial interest in the knee joint, I have spent very many enjoyable and profitable hours browsing through this excellent treatise. In his section on the function of the all-important ligaments of the knee, Dr. DePalma has been extremely lucid and has pointed out the gross failure of many to understand the importance of the functioning of these ligaments in the various positions of the knee. This section is a *must* for the young orthopaedist who is seeking to advance his knowledge in this important matter. The points of agreement with Dr. DePalma are many more than those of disagreement; even in certain situations in which one might not wholly concur with his conclusions and recommendations, one cannot deny that the position taken is backed by very careful consideration for the function of the various elements of the knee.

Physically, this is an extremely attractive book. The publisher should be congratulated on the format and the type which is extremely easy to read. The cuts are clear and well labeled. In many instances the legends of the illustrations are sufficiently self-explanatory that reference to the text is not necessary. I do not hesitate to recommend this book without qualification to the student, general practitioner, or specialist.

Don H. O'Donoghue, M.D.

Instructional Course Lectures. Vol. XI. The American Academy of Orthopaedic Surgeons, 1954. Edited by the Program Committee on Instructional Courses: Sam W. Banks, M.D., William A. Larmon, M.D., Herbert W. Virgin, Jr., M.D., Robert L. Patterson, Jr., M.D., R. Beverly Raney, M.D., *Chairman*. Ann Arbor, J. W. Edwards, 1954. $12.00.

The present volume of Instructional Course Lectures resembles the previous volumes and contains much valuable information on a variety of subjects. Included are two excellent symposia, — one on Soft-Tissue Tumors of the Extremities by Dr. Ralph K. Ghormley and Members of the Staff of the Mayo Clinic and one on Intervertebral-Disc Lesions and Low-Back and Leg Pain by Dr. J. Albert Key and his associates. In addition to chapters on subjects peculiar to orthopaedic surgery, such as fractures, arthroplasty of the hip, and surgical approaches to the knee and hip, this volume contains worth-while chapters on related subjects, such as vascular and nerve injuries, fluid balance, and complications of general anaesthesia. Along with its predecessors, this volume deserves a place in every orthopaedic library.

Thornton Brown, M.D.

Human Limbs and Their Substitutes. Presenting Results of Engineering and Medical Studies of the Human Extremities and the Application of the Data to the Design and Fitting of Artificial Limbs and to the Care and Training of Amputees. Paul E. Klopsteg, Ph.D., Sc.D., Philip D. Wilson, M.D., et al. Prepared under the sponsorship of the Advisory Committee on Artificial Limbs, the National Academy of Sciences, the National Research Council. In summary and correlation of a research program for the Department of Medicine and Surgery, U. S. Veterans Administration, and for the Office of the Surgeon General, Department of the Army. New York, McGraw-Hill Book Company, Inc., 1954. $12.00.

For nearly a decade the Advisory Committee on Artificial Limbs, working under the National Research Council of the National Academy of Sciences, has been carrying on a remarkable program of basic and clinical research directed toward the development of vastly more serviceable and efficient artificial limbs. This work is in the nature of a research report summarizing the present status of each segment of the program. The thirty-two contributors — surgeons, engineers, physiologists, psychologists, therapists, prosthetists, chemists, and manufacturers — ably represent the many integrated fields involved. The book itself is divided into four parts: (1) *The Medical Problems of the Amputee* includes the influences of new developments on amputation surgery, phantom limb, psychological adjustment, and the principles of prosthetic prescription; (2) *The Upper Limb and its Substitutes* embraces the biomechanics of the upper extremity, the mechanics of voluntary muscle, and the developments in prosthetic hands, hooks, cosmetic gloves, and upper-extremity prostheses; (3) *The Lower Limb and Its Substitutes* deals with the functional structures of the lower limb, locomotion, and new developments in lower-extremity prostheses; and (4) *The Adjustment of the Limb to the Amputee* presents the problems involved in fitting, alignment, training of the amputee, and artificial-limb evaluation. This volume is neither a textbook on surgery or prosthetics nor a clinical reference work. It is a treasury of prosthetic developmental research and is excellent throughout; it is, however, somewhat tedious to the physician in its technical non-medical aspects.

Donald B. Slocum, M.D.

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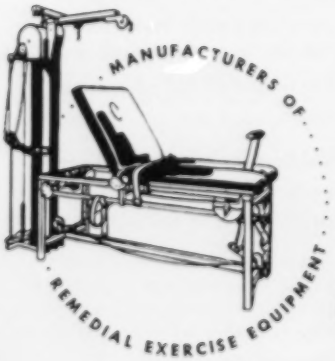

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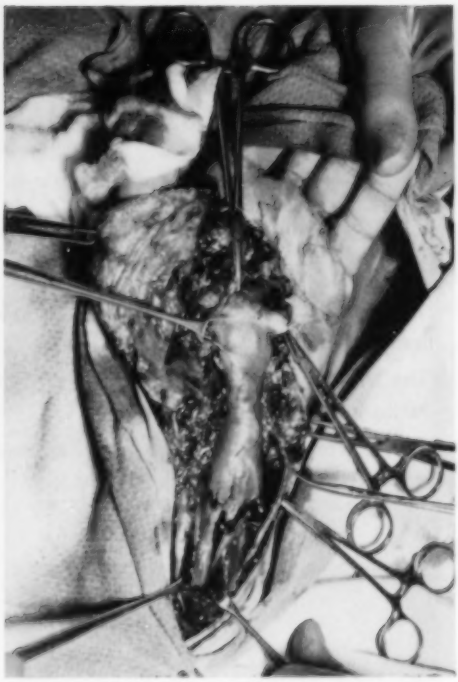

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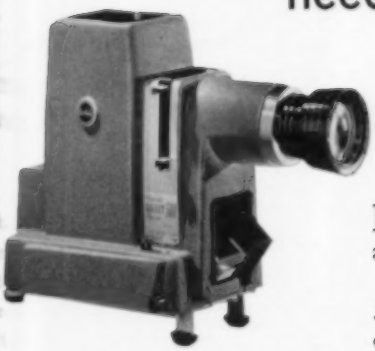

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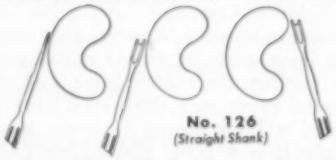

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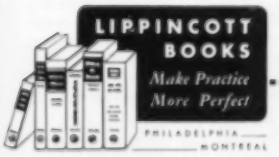

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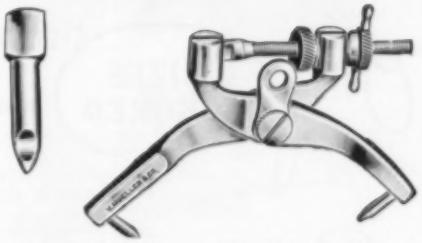

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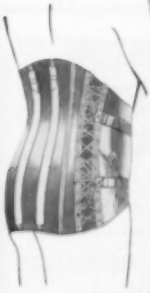

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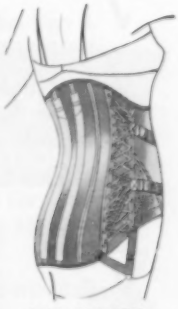

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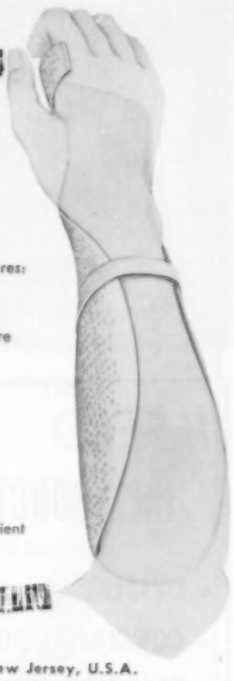

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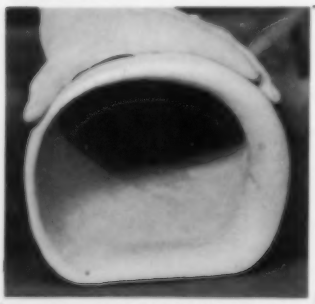

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JUNE 1955

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